AD-A092 924 ARMY COMMAND AND GENERAL STAFF COLL FORT LEAVENWORTH KS F/G 5/9

A LINEAR PROGRAMMING APPLICATION TO AIRCREW SCHEDULING.(U)

JUN 80 C L PANNELL

UNCLASSIFIED SBIE-AD-E750 038 NL

1 of 2

AD

A092924

AD E750 038

A LINEAR PROGRAMMING APPLICATION TO AIRCREW SCHEDULING

2 LEVEL III

AD A092924

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

CARLTON L. PANNELL, MAJ, USAF
B.A., California Western University, 1964

DTIC
ELECTE
DEC 17 1980
S D
B

Fort Leavenworth, Kansas
1980

DDC FILE COPY

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

80 12 08 021

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A092	3. RECIPIENT'S CATALOG NUMBER 924
4. TITLE (and Subtitle) A Linear Programming Application to Aircrew Scheduling		5. TYPE OF REPORT & PERIOD COVERED 6 June 1980
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Pannell, Carlton L., Maj, USAF		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Student at the U.S. Army Command and General Staff College, Fort Leavenworth, Kansas 66027		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Command and General Staff College ATTN: ATZLSW-DC-MS		12. REPORT DATE 6 June 1980
		13. NUMBER OF PAGES 140
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Approved for public release; distribution unlimited.

18. SUPPLEMENTARY NOTES

Master of Military Art and Science (MMAS) thesis prepared at CGSC in partial fulfillment of the Masters Program requirements, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas 66027

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Linear Programming

Aircrew Scheduling

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See reverse

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

This study presents an evaluation of the use of linear programming in maximizing aircrew combat readiness by optimizing allocation of training sorties based on current training requirements and individual aircrew capabilities. The research focuses on an A-7D fighter squadron but the general principals are applicable to other fighter units.

This study demonstrates the feasibility of using linear programming and computer assisted techniques to improve the efficiency of allocating training sorties in a fighter squadron. The study also identifies shortfalls in TAC's existing computer systems and lack of necessary programs to measure aircrew proficiency. The conclusion of the study is that while the application of linear programming techniques may improve the overall efficiency of sortie allocation, it is not currently possible to implement such a system without further research and development of supporting systems. Therefore, it is recommended that additional research be devoted to refinning the techniques presented in this study for use as computer terminals become available within individual squadrons.

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes

Dist	Avail and/or Special
A	

A Linear Programming Application to Aircrew Scheduling

Carlton L. Pannell, Maj, USAF
U.S. Army Command and General Staff College
Fort Leavenworth, Kansas 66027

6 June 1980

Approved for public release; distribution unlimited. [redacted].

A Master of Military Art and Science thesis presented to the faculty of the U.S. Army Command and General Staff College, Fort Leavenworth, Kansas 66027.

MASTER OF MILITARY ART AND SCIENCE

THESIS APPROVAL PAGE

Name of candidate: Maj Carlton L. Pannell.

Title of thesis: A LINEAR PROGRAMMING APPLICATION TO AIRCREW SCHEDULING.

Approved by:

______________________, Thesis Committee Chairman
Capt R. E. Blankenship, MBA

______________________, Member, Graduate Faculty
Lt Col M. W. Schooff, MS

William B Allard, Member Consulting Faculty
Maj W. B. Allard, PHD

Accepted this 11th day of June 1980 by Philip J. Brookes, Director, Graduate Degree Programs.

The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

A LINEAR PROGRAMMING APPLICATION TO AIRCREW SCHEDULING, by Major Carlton L. Pannell, USAF, 141 pages.

This study presents an evaluation of the use of linear programming in maximizing aircrew combat readiness by optimizing allocation of training sorties based on current training requirements and individual aircrew capabilities. The research focuses on an A-7D fighter squadron, but the general principals are applicable to other fighter units.

This study demonstrates the feasibility of using linear programming and computer assisted techniques to improve the efficiency of allocating training sorties in a fighter squadron. The research also identifies shortfalls in TAC's existing computer system and lack of necessary programs to measure aircrew proficiency. The conclusion of the study is that while the application of linear programming techniques may improve the overall efficiency of sortie allocation it is not currently possible to implement such a system without further research and development of supporting systems. Therefore, it is recommended that additional research be devoted to refining the techniques presented in this study for use as computer terminals become available within individual squadrons.

ACKNOWLEDGEMENTS

I would like to acknowledge the considerable assistance provided by Mr Edgar Arendt in developing the FORTRAN computer assisted scheduling program and in working with the Control Data Corporation APEX III software package.

TABLE OF CONTENTS

	Page
APPROVAL	ii
ABSTRACT	iii
ACKNOWLEDGEMENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	viii
Chapter	
I. INTRODUCTION	1
Background	1
Problem Statement	3
Objective	4
Flying Training	5
Scheduling	12
Automated Flying Training Management Systems	16
II. RESEARCH DESIGN AND PROCEDURES	18
Introduction	18
The Squadron Composition	19
Definition of Variables	20
Constraints	23
Linear Equations and Inequalities	28
III. PROGRAM AND SOLUTION	34
Computer Program	34
Computer Solution	47

IV. ANALYSIS AND CONCLUSIONS 55

V. SUMMARY AND RECOMMENDATIONS 60

APPENDIXES

A. DEFINITIONS AND ABBREVIATIONS 62

B. MATHEMATICAL OVERVIEW 66

C. VARIABLE LISTING 72

D. FORTRAN COMPUTER ASSISTED SCHEDULING PROGRAM 75

E. FORMATTED INPUT 87

F. COMPUTER SOLUTION 103

G. SCHEDULER'S HANDBOOK 124

BIBLIOGRAPHY 140

LIST OF TABLES

Table		Page
1.	Semiannual Requirements	7
2.	Active Duty A-7D Training Program	8
3.	Collateral Sortie Computation	9
4.	A-7D Required Hits	10
5.	A-7D GCC Event Training Program	11
6.	Aircrew/Aircraft Planning Factors	12
7.	Pilot Categorization	21
8.	Pilot Ranking	22
9.	Maximum CT Sortie Requirements	26
10.	Minimum CT Sortie Requirements	27
11.	Minimum Sortie Adjustment Factors	28
12.	Sortie Distribution	30
13.	Variables	73

LIST OF FIGURES

Figure		Page
1.	Available Flying Days	24
2.	Available Sorties per Day	25
3.	Dimension Table	37
4.	Dimension Table Key	38
5.	Flow Chart	40
6.	LP Input	45
7.	Sortie Allocation Work Sheet	127
8.	Question/Response	128
9.	Statement/Response	130
10.	Level One	132
11.	Level Two	135
12.	Level Three	137

Chapter I

INTRODUCTION

Background

From the late 1960s until the termination of the Vietnam conflict, numerous deficiencies existed in training of Tactical Air Command (TAC) aircrews. Aircrews were sent into combat with little experience in their assigned aircraft and with little or no specialized mission training. (22:5) TAC recognized aircrew training programs required revision and in 1972 conducted a Tactical Fighter Symposium to study the problems and develop recommendations to improve the situation. (22:8)

In 1973, a conference was held at Headquarters United States Air Force to evaluate a new idea in aircrew training. (22:9) Out of this meeting came the Designed Operational Capability (DOC) concept. This concept directed individual units be assigned specific training missions or DOCs.

In July of the following year, the new training concept was implemented with the publishing of a multi-command 51- series manual. (22:9) The basic manual was divided into individual volumes covering each of the aircraft assigned to the Tactical Air Forces (TAF). The basic volume outlined the flying training program in terms of a multi-level approach to matching available resources and training requirements called a Graduated Combat Capability.

Again in 1976, the Air Force took action to verify the status of aircrew training programs in TAC. Air Force directed the Air Force Inspection System Command (AFISC) to perform a Functional Management Inspection (FMI) to identify aircrew training problems and "zero-in" on areas adversely impacting on the quality of aircrew training. The team visited the Air Staff, five major command (MAJCOM) headquarters, and twenty-four air bases within the TAF. The inspection methods used were questionnaires and in-depth interviews with commanders, staffs, and aircrews. (6:1)

Several complex, interrelated problems concerning aircrew training were surfaced by AFISC. Although these problems had been getting worse for years, the true effects were masked due to the highly qualified aircrews. (6:1) The lower experience levels found in fighter units today, coupled with economic and personnel constraints, have highlighted the need to correct existing deficiencies before too much damage occurred to the overall level of combat readiness. The basic finding of the FMI was that flying units needed tailored training programs optimized to programmed wartime tasks and unique unit situations. (6:2)

Today, Air Force military end strength is at its lowest point since 1950. (15:135) Between 1973 and 1979, the Air Force accounted for over sixty percent of the total Department of Defense (DoD) active military reductions. In addition, over the last ten years Air Force manpower declined by thirty-seven percent while military costs increased by thirty percent. (15:136 and 143) Since 1968, our total force -- Air National Guard (ANG), Air Force Reserve (AFRES), and Active duty -- aircraft inventory has dropped from over 15,000 aircraft to a'most

9,000 aircraft (a reduction of forty-one percent). During this same period, the total number of flying hours was reduced by fifty-eight percent, yet the operating costs increased by seventy-five percent. (15:144)

The TAF is faced with many constraints to providing optimum training to today's fighter force. Fewer resources, budgetary limitations, and lower aircrew experience levels are the main restrictions. As flying hours and training sorties are cut, it becomes imperative to efficiently allocate the available sorties to ensure adequate readiness of the fighting force.

> Readiness is a concept that integrates the diverse factors that affect the ability to deploy, engage, and sustain effective combat forces. It starts with the overall availability and proficiency of U.S. fighting men. (18:1)

TAF's aircrew training is a readiness issue which has considerable impact on this nation's combat capability. To satisfy the need for a strong tactical air arm, the TAF developed basic aircrew training programs designed to be tailored to the needs and capabilities of the individual aircrews. My experience has been that too many of the units assigned to TAC try to meet the standards of training manuals, rather than attempt to really tailor the flying training program to the individual's abilities.

Problem Statement

The basic problem then is to develop a system or program which will allow the individual squadron scheduler to allocate available training sorties in a way which will not only meet training guidance but also satisfy the training needs of individual aircrews based on their proficiency. Training sorties are allocated to pilots so they

can attain or maintain proficiency. The allocation process is meant to provide proficient crews and a combat ready squadron. (10:10) The state of combat readiness of the squadron depends on the proficiency of individual pilots. To ensure that each pilot can maximize his proficiency within the constraints of available resources, each pilot must be allocated sufficient sorties to maintain the desired proficiency level. To be effective any system or program must be simple and easy to use. It must be flexible and responsive to the needs of the scheduler since the guidelines and resources which are availabe to the scheduler change frequently. While there may be many suitable programs or systems which would meet these goals (linear programming, dynamic programming, goal programming, etc.), only one approach will be studied due to the limited time available for research.* Due to the simplicity of a linear programming approach and the availability of software to solve very large linear programming models, this research will focus on the possible use of linear programming as an aircrew scheduling aid.

Objective

The objective of this study is to determine if linear programming can be employed to improve scheduling effectiveness by distributing sorties based on the priorities assigned by the scheduler. Although this study is limited to units possessing the A-7D aircraft, the application of linear programming techniques should be equally valid for units with other tactical weapons systems. To be able to

*A brief discussion of linear programming, dynamic programming, and goal programming can be found in Appendix B.

apply to linear programming techniques, one must be familiar with flying training regulations and scheduling problems.

Flying Training

Multi-command manual 51-50, Tactical Fighter/Reconnaissance Aircrew Training, establishes the flying training program for TAF aircrews referred to as the Graduated Combat Capability (GCC). (12:1-1) The GCC concept is a three level approach which attempts to match resources and training requirements. The levels are defined as:

> 1. Level A. This is the basic mission ready standard, as determined by the MAJCOM, and reflects the minimum level to which a crew must be trained to perform the unit's primary mission.
>
> 2. Level B. Additional training required to increase proficiency, lower crew/aircraft attrition, and increase the capability to accomplish the unit's full tasking.
>
> 3. Level C. This level represents the complete training program for the unit based on full employment tasking. (12:1-2)

Associated with the three levels of training are three progressive phases which an aircrew transitions. The three phases are defined as:

> 1. Initial Qualification Training (IQT). The training to initially qualify an aircrew in basic flying duties regardless of the unit's operational mission.
>
> 2. Mission Qualification Training (MQT). That training in addition to IQT needed to progress the aircrew to designated mission status.
>
> 3. Continuation Training (CT). The training for a qualified aircrew member to maintain mission status... (12:1-2)

Another categorization which must be understood is mission status. Aircrews are either mission ready (MR) or mission support (MS). An MR aircrew is one who can be sent into combat and accomplish

the unit's primary mission without additional training. An MS aircrew is one who maintains basic qualifications, but would not enter combat without additional training to reach MR status. (12:1-3)

Both MR and MS aircrews are further classified by experience level. Aircrews are designated as either experienced or inexperienced based on the number of hours flown and the type of aircraft in which the hours were accumulated. An experienced aircrew must meet the following criteria:

1. 1000 or more total hours flying time and 300 hours minimum in the unit aircraft, or

2. At least 500 hours in the unit aircraft, or

3. 100 hours in the unit aircraft and previously categorized as experienced in a specified tactical aircraft. (12:1-3)

Those aircrews who do not meet the above requirements are designated inexperienced.

The sortie program outlined in multi-command manual 51-50 is built around a minimum and standard sortie basis. The standard sortie program sets forth the optimum requirements which must be flown to maintain an assigned training level. The minimum sortie program establishes the least number of sorties which must be flown to maintain an assigned training status. These two programs are further divided into specific sortie types and events which must be accomplished during each six month training cycle.

The minimum sortie and event requirements for all aircrews flying fighter aircraft are listed in Table 1. (12:1-4) This training should be scheduled to ensure a regular sortie flow is accomplished by individual aircrews. (10:34) A regular or steady flow of training is

needed to keep aircrews from losing proficiency or currency in an event or type of mission. Sorties which must be used to regain currency reduce the number of training opportunities which can be used to complete GCC tasking.

Table 1

Semiannual Requirements

Crew Position	Instrument Penetrations	Precision Instrument Approaches	Nonprecision Approaches	Night Landings	Night Sorties	Minimum Total Sorties	Air Refueling MR/MS
Pilot	6	12	12	2	2	30	3/2

With the minimum sortie requirements established, the next consideration is the standard sortie program which establishes the specific guidance for developing unit training programs. Since this study concentrates on an A-7D unit, Table 2 presents an illustrative active duty A-7D training program extracted from TAC Manual 51-50, Vol III. (13:3-3)

Table 2

Active Duty A-7D Training Program

	Level A		Level B	Level C	
	Day	Night		Day	Night
Sorties					
WD/SAT[a]	22/18	6	11/6	1	9/5
Maverick[b]	6		4/2	2	
SAR[c]			(8/6)	(2)	
ACBT[d]	6		4/2	2	
Subtotal GCC	34/30	6	19/10	14/10	
Total GCC	40/36		59/46	73/56	
Total	50/46		71/57	86/68	

Note: See Appendix A for an explanation of the sortie types.

a. Weapons Delivery/Surface Attack Tactics
b. Sorties employing captive or live Maverick air-to-ground missiles
c. Search and Rescue
d. Air Combat Training

The numbers under the columns labeled Level A, Level B, and Level C in Table 2 are broken out according to the requirements for inexperienced/experienced aircrews respectively. Level A shows the minimum sorties needed to maintain an MR status. Level B lists the added sorties recommended by TAC when a unit can provide more sorties than required to maintain Level A. Level C includes the remaining sorties to meet TAC's overall training goal. While the subtotal and total GCC tasking is self-explanatory, the difference between total GCC and total sorties is not readily apparent. This difference results from the addition of collateral sorties to the GCC requirements to cover unprogrammable requirements.

Collateral sorties are additional sorties which are used for planning purposes to allow for training directed by Air Force requirements (checkrides, deployments, etc.), upgrade sorties, recurrency

sorties, and non-effective GCC training sorties. For computational purposes, collateral sorties are determined by taking ten percent of the total GCC sorties and adding six more sorties. (12:4-4) Table 3 illustrates the computation of total planning sorties.

Table 3

Collateral Sortie Computation

Total GCC Sorties +	Collateral Sorties =	Total Planning Sorties
15-24	8	23-32
25-34	9	34-43
35-44	10	45-54
45-54	11	56-65
55-64	12	67-76
65-74	13	78-87
75-84	14	89-98
85-94	15	100-109

Flying the total number and type of sorties listed in Table 2 is insufficient in itself to maintain a given aircrew status. Aircrews must also meet the GCC event training program requirements. The event training program sets a qualification or proficiency level and a minimum number of event repetitions which must be attained. Of the events required, the weapons delivery qualification is the most important.

To establish and maintain a weapons delivery qualification, an aircrew must meet the standards for each type of delivery which his level of training dictates. Each type of delivery event has scoring criteria which determines if a given delivery is a hit (qualifying) or a miss (not qualifying). To qualify in a delivery event, a minimum number of hits must be achieved. Additionally, fifty percent of conventional ordnance deliveries and forty percent of Maverick deliveries must be hits. Table 4 shows the minimum required hits per type

delivery event (bombing, strafe, and Maverick) based on the type of range used for scoring the delivery. (12:5-5)

Table 4

A-7D Required Hits

Type Event/Delivery		Hits
Conventional Ordnance		
Conventional Range		6/4
Tactical Range		3/5
	TOTAL	9/9
Strafe		
Conventional Range		6/4
Tactical Range		-
	TOTAL	6/4
Maverick		6
	TOTAL	6

Note: Hits are listed in order for inexperienced/experienced pilots.

To illustrate qualification requirements, an example using an experienced aircrew on a conventional range, dropping conventional ordnance will be presented. If the experienced aircrew were to drop four qualifying bombs consecutively, he would be qualified, since he achieved the minimum number of qualifying deliveries by Table 4. However, if the same aircrew were to have four consecutive misses, he would then have to drop at least four more bombs, all hits, to reach fifty percent hits and therefore be qualified.

Requirements of the GCC event training program vary just as the sortie program depending on the level of training assigned. The specific requirements based on Levels A, B, and C are listed in Table 5. There are additional constraints not apparent from looking at the table. First, night events listed in Table 5 are only required

Table 5

A-7D GCC Event Training Program (13:3-5)

Event	Level A		Level B	Level C	
	Day	Night		Day	Night
Computed Low Angle Strafe	Qual				2
Computed Low Angle Bomb	Qual				2
Computed Low Angle Low Drag	Qual	Fam			Qual
Computed Dive Bomb	Qual	Fam			Qual
Computed High Altitude Dive Bomb			Fam	Qual	Fam
High Angle Strafe			Fam	Qual	Fam
Flare Delivery		1(Opt)			Fam
Air Support Radar Team Delivery			2	1	
Low Level Visual Navigation	6		2	3	
Night/Tactical/Radar Navigation		1			2
Surface Attack Tactics with FAC	2	1(Opt)	2	1	2
Surface Attack Tactics Alert			2	2	
Maverick			Qual		
Full Scale Weapons Delivery			1	1	
Composite Force Training			2	1	1
Radar Deliveries (Day or Night)		1			2
Electronic Warfare Range Training	12			1	
Search and Rescue			2	1	
Helicopter Escort			2	1	

Notes.

1. Qual means qualification is required.
2. Fam means that the aircrew is to be familiar with the event but qualification in the event is not required.
3. Opt means the event is optional.

if the unit is tasked to maintain a night capability. Second, deliveries performed during WD sorties and/or SAT sorties, either day or night, may be counted for WD qualifications. Lastly, at least two deliveries in each weapons event must be performed in a manual mode.

Scheduling

Squadron schedulers face a difficult job. (24:40) They must attempt to maximize crew proficiency, morale, and safety while ensuring available resources are neither over nor under used. Schedulers must function in a very fluid environment where availability and priorities of individual aircrews, training areas, suitable weather conditions, and aircraft compound the problem of achieving training objectives. When the scheduler looks at aircrew availability he must consider several factors including the number of aircrews involved, their experience level, priorities of individuals, and the frequency of personnel turnovers.

The aircrews assigned to a squadron are based on the number of aircraft the unit is authorized. Air Force Pamphlet 173-13, USAF Cost and Planning Factors, sets the ratio of aircrews to aircraft. For an A-7D unit the aircrew/aircraft ratio is 1.25 to 1.0. Table 6 shows the relationship for two normal sized squadrons. (8:156 and 159)

Table 6

Aircrew/Aircraft Planning Factors

Type of Aircraft	Aircraft Authorized	Manning Ratio	Authorized Aircrews	Staff Active	Staff ANG
A-7D	24	1.25	30	7	13
A-7D	18	1.25	23	-	13

Based on an active duty A-7D unit with twenty-four aircraft and a 1.25 manning ratio, the scheduler would be working with thirty primary aircrews and seven staff aircrews. Assuming a forty percent experienced ratio for aircrews, the squadron would be made up of twelve experienced primary aircrews and eighteen inexperienced primary aircrews.* The seven staff aircrews would normally meet the requirements for designation as experienced aircrews.

Although the number and experience level of assigned aircrews is a basic consideration, it is still necessary to determine or establish the priority which each aircrew should be given when allocating available sorties. The GCC program provides priority to inexperienced aircrews over experienced aircrews but leaves any other guidelines to be established by the unit commander. This aspect becomes critical when there are insufficient sorties for each member of the unit to meet the training standards and some of the aircrews need extra training to achieve required standards.

Today, personnel policies provide for stabilized three year tours at most bases. To the scheduler this means the unit will lose, on the average, one-third of its members each year. For planning purposes, this turnover equates to five new aircrews per six month training cycle.

The unit training program must efficiently transition new aircrews from IQT through MQT and into CT in as brief a period as

---

*In Volume III of the Rated Distribution and Training Management Executive Committee Minutes (published semiannually) the aircrew experience ratio is addressed by base and weapons system. While the ratio varies from unit to unit, the ratio for TAC, as a whole, is close to 40/60.

possible. To accomplish this task, the scheduler must be familiar with the requirements and time constraints associated with each phase of training (IQT, MQT, and CT).

The IQT program consists of ten base sorties; however, more sorties may be flown if needed. The first eight sorties are prerequisites for the initial qualification/instrument check on the ninth sortie. The tenth sortie is a night transition sortie which may be accomplished in conjunction with the night sortie in the MQT phase. All ten sorties must be flown with an IP and completed in less than two months. (13:1-1 - 1-4)

Upon completion of IQT aircrews may enter MQT or CT depending on the final status (MR/MS) to be achieved. Aircrews expected to maintain an MS status do not have to complete MQT. The number of sorties to be flown during MQT is determined by the unit commander based on the upgrading aircrew's experience, the assigned GCC level, and ensuring training continuity. The MQT phase must be completed within a two month time frame. (12:3-1 - 3-3)

To enter CT aircrews must have completed IQT and MQT or equivalent training. Since specific CT requirements were discussed in the previous section, the requirements will not be repeated here. It is important to note that it may take at most four months to complete both IQT and MQT which would leave two months of CT to be accomplished.

The CT requirements can be prorated based on the following formula:

$$\frac{\text{Months available}}{6} \times \frac{\text{Events/sorties/hours}}{\text{required per six month}} = \text{Prorated Requirement}$$

Fractions of .5 or greater will be rounded to the next larger number. Those fractions less than .5 will be dropped. (12:1-5) An individual who has only two months left in the training cycle would have to complete one-third of the CT requirements.

In addition to normal training sorties, aircrews must take an annual instrument and qualification checkride. These checkrides must be accomplished with a Standardization/Evaluation Flight Examiner (SEFE). This requirement results in a need for thirty-seven or more sorties per training cycle. Additional sortie requirements result from the various upgrade programs (flight lead, instructor pilot, etc.).

The next major area facing the scheduler is the availability of training areas. There are very limited numbers of low level training routes, weapons ranges, and airspace for air-to-air work which individual units can use on a daily basis. Most of these training areas must be shared with other units which limits the number and type of sorties which can be flown each day by any one unit. Additionally, weather may preclude use of an area even if it was available to the unit.

Weather is an important factor in developing any flying schedule. TAC Manual 25-5, Programmed Flying Training Factors, provides the scheduler with charts on the expected days suitable for flying at specific bases. (11:A5-1 - A5-5) The local weather officer is also important as a source for historical data on both seasonal and daily weather conditions. Knowledge of the weather is critical because it determines not only if flying is possible, but when flying can be accomplished, what areas can be used, and what type of mission can be flown.

The type and number of available sorties is also dependent on the maintenance capabilities of the unit. With a squadron of twenty-four aircraft, fifteen aircraft would normally be flyable to meet the daily flying schedule. Normal use rates would provide about twenty-two sorties per day.*

In addition to the factors which limit the amount of training which can be accomplished, the scheduler must be aware of the need to maintain accurate records of completed training so that requirements can be forecast. Tracking of training accomplishments and currency is a considerable task. Recognizing the benefits to be gained by employment of an automated system to perform these tasks, the MAJCOMs developed and implemented their own computerized management systems.

Automated Flying Training Management Systems

Today, the Military Airlift Command (MAC) has its Automated Resources Management System (MACARMS), the Strategic Air Command (SAC) has its Automated Resources Management System (SACARMS), and TAC has its Automated Flying Training Management System (TAFTRAMS). Actions are underway to combine all of these individual systems into one Air Force wide Operations Resources Management System (AFORMS) in the 1982 time period. Since this study deals with TAC requirements and systems, only TAFTRAMS will be discussed in this section.

---

*Computation of available aircraft and sortie generation capability is developed in Chapter II on pages 24 and 25.

TAFTRAMS was developed to:

> ... record and track continuation training activities required by applicable MAJCOM 51-series manuals for use by unit level managers and to support the flow of summarized data to higher headquarters agencies. (14:1-1)

To attain this goal, TAFTRAMS was designated as the official record of CT accomplishments and each unit in TAC was directed to use the system to monitor training directed by MAJCOM 51-series manuals.

TAFTRAMS is a computerized management system developed, tested, and modified by TAC. It is currently a batch processing system run by the local Data Processing Installation (DPI) on Burroughs model 3500/3700/4700 computers. (14:2-4) While the capability to run the system on a daily basis exists, units normally request updates only three times a week. The time span from delivery of the card deck to the data processing center to receiving the computer print-outs is normally overnight.

Computer input data is created from pre-punched or manually punched standard eighty character cards. During a regular cycle up to 5,000 cards can be input. A greater number of cards can be input only with special coordination with the DPI.

Processing time in the Central Processing Unit varies with the

> ... number of other programs running concurrently in the computer, the number of aircrews, and the amount of data stored for each (i.e., the later in the training cycle, the longer the run time). (14:2-8)

Access to and time on the computer is somewhat determined by the other base agencies which also use the system. Considerable justification is required for any increased use or cost associated with the DPI.

Chapter II

RESEARCH DESIGN AND PROCEDURES

Introduction

The objective of this thesis is to determine if linear programming can be used as a management tool to improve scheduling effectiveness by allocating sorties based on priorities assigned by the squadron scheduler. To determine if linear programming can be used as a scheduling aid, a linear programming model will be developed and used in conjunction with a computer program to generate a squadron sortie allocation for one training cycle. The constraints of the linear model will be modified to evaluate the effects on the sortie allocating process.

This chapter is divided into four subsections. In the first section an imaginary squadron is constructed for use in the linear programming model. Individual pilots are identified with alphanumeric characters and their specific qualifications and characteristics are delineated. In the next section an explanation of the system used to designate the variables in the mathematical model is provided. In the third section the scheduling constraints are developed. The final section illustrates a representative sample of the mathematical relationships which exist based on the considerations of the first three sections.

The Squadron Composition

To formulate the linear program, a basic A-7D unit will be established with current manning factors. This squadron will be based on an active duty squadron with twenty-four aircraft. Manning for the squadron will be based on guidelines found in Air Force Pamphlet 173-13, USAF Cost and Planning Factors, which are summarized in Table 6, page 12. The squadron will consist of thirty primary pilots. Twelve of the thirty pilots would be experienced and the remaining eighteen would be inexperienced. Of the twelve experienced pilots, three will be designated as instructor pilots (IPs). In addition to the thirty primary pilots, there will be seven staff pilots. All seven of the staff pilots will be considered experienced. Three of the staff will be IPs (one of the IPs will be a SEFE) and the remaining four will be MS pilots. Table 7, page 21, provides a summary of the applicable pilot categorizations.

Since each pilot is unique and possesses distinct abilities, it is possible to develop programs to rank the pilots according to their proficiency in comparison with other unit pilots. Some objective programs already exist to rank pilots (such as TOP GUN competition) and some programs will have to be developed.* Where objective measurement systems do not currently exist, subjective rankings could be used with

*TOP GUN competition is a common practice in TAC fighter squadrons. While there are many variations, the pilots are ranked in each weapons delivery event according to their number of hits and/or average miss distance from the target.

only a marginal degradation in results.* To develop rankings for this imaginary squadron a monte carlo simulation approach was used.** A randomly generated number was assigned to each pilot and the resultant distribution was then employed to artificially order the pilots from top to bottom. An unweighted ranking from each type sortie was used to determine an overall position within the squadron. These rankings are depicted in Table 8, page 22.

Definitions of Variables

The variables for this problem represent the number of each type sortie flown by each unit pilot under its current GCC tasking. Each of the thirty-seven pilots assigned to the squadron may fly seven different types of sorties resulting in a total of 259 variables. The general notation for the variables is XPPSS, where PP is the pilot number and SS is the sortie type.*** The alphanumeric designators for the variables are listed for each pilot in Appendix C.

---

*If each of the squadron IPs subjectively rank all of the pilots in each type of sortie and a composite ranking is developed from these separate lists, the relative pilot rankings are not likely to significantly differ from a ranking developed through a very systematic approach.

**For a discussion of monte carlo simulation the reader should consult Modern Elementary Statistics by John E. Freund or An Introduction to Quantitative Methods for Decision Making by Richard E. Trueman.

***The numeric designators for the various sorties are: 01 (WD), 02 (SAT), 03 (MAV), 04 (ACBT), 05 (SAR), 06 (NIGHT), and 07 (COLS).

Table 7

Pilot Categorization

Pilot Designator	Primary Aircrew		Staff		Experience Level		Instructor Pilot
	MR	MS	MR	MS	Exper	Inexper	
P1				X	X		
P2	X					X	
P3	X				X		
P4	X					X	
P5	X				X		X
P6	X				X		
P7	X				X		
P8				X	X		
P9	X				X		X
P10	X					X	
P11	X					X	
P12	X					X	
P13			X		X		X
P14	X				X		
P15	X					X	
P16			X		X		X
P17	X					X	
P18	X				X		
P19	X					X	
P20	X					X	
P21			X		X		
P22	X					X	
P23	X				X		X
P24	X					X	
P25	X					X	
P26	X					X	
P27				X	X		
P28	X					X	
P29	X					X	
P30	X				X		
P31	X				X		
P32	X					X	
P33	X				X		
P34	X					X	
P35	X				X		
P36			X		X		X
P37	X					X	

Table 8

Pilot Ranking

Group*	Ranking	WD	SAT	MAV	ACBT	SAR	Overall Position
		Type Sortie					
I	1	P14	P23	P36	P10	P26	P23
	2	P16	P9	P13	P18	P3	P9
	3	P9	P18	P9	P13	P16	P5
	4	P32	P11	P14	P5	P23	P14
II	5	P11	P31	P18	P37	P37	P7
	6	P7	P7	P17	P30	P33	P18
	7	P5	P5	P29	P19	P21	P16
	8	P23	P14	P32	P26	P35	P33
	9	P31	P33	P23	P6	P28	P3
	10	P19	P2	P24	P9	P34	P29
	11	P2	P29	P35	P23	P36	P31
III	12	P27	P27	P20	P12	P7	P13
	13	P35	P28	P7	P3	P2	P6
	14	P17	P4	P4	P32	P5	P36
	15	P20	P13	P6	P29	P11	P26
	16	P3	P36	P27	P31	P15	P32
	17	P24	P3	P33	P4	P22	P37
	18	P15	P20	P15	P15	P6	P11
	19	P25	P6	P5	P33	P20	P4
	20	P29	P22	P1	P16	P30	P2
	21	P26	P16	P37	P2	P24	P20
	22	P6	P30	P28	P22	P12	P35
	23	P34	P25	P12	P36	P31	P15
	24	P33	P10	P30	P1	P19	P19
	25	P4	P17	P26	P25	P32	P28
	26	P10	P34	P16	P24	P14	P25
IV	27	P12	P21	P19	P14	P17	P17
	28	P18	P35	P31	P34	P29	P30
	29	P28	P12	P3	P20	P9	P24
	30	P8	P26	P25	P7	P13	P12
	31	P1	P37	P21	P11	P18	P10
	32	P13	P15	P8	P28	P4	P34
	33	P36	P8	P11	P8	P25	P22
V	34	P37	P1	P10	P35	P8	P27
	35	P30	P32	P22	P27	P10	P21
	36	P22	P24	P34	P17	P27	P1
	37	P21	P19	P2	P21	P1	P8

*Use of this column is addressed on page 26.

Constraints

The constraints which the scheduler faces fall into four categories: (1) the number of sorties which can be supported by the available aircraft, (2) the number of each type of sortie which can be supported with other resources, (3) training requirements from applicable guidance, and (4) the training required due to individual pilot proficiency.* These constraints will be covered in order and the mathematical relationships will be developed using the variables listed in Appendix C.

The first consideration is the total number of sorties available from the twenty-four assigned aircraft. TAC Manual 25-5, Programmed Flying Training Factors, provides the basic standards used for computations involved in determining sortie availability.** Two factors are needed, the number of flying days available and the number of sorties which can be flown per day. Figure 1 shows the computation of available flying days for planning purposes. This data is combined with the data in Figure 2 which shows the computation of the number of sorties available per day to determine the total sorties available. When the data from these two figures are combined it can be determined that 2,024 sorties would be available in the

*The variability of weather conditions and availability of the areas from one location to another will not be specifically covered but are usually taken into account when determining the total number and type of sorties available for planning.

**The computation of available flying training days is covered in Attachment 5 and the computation of aircraft utilization and generation rates is covered in Attachment 10 of the manual.

first training cycle (January - June) and 2,464 during the second training cycle (July - December) for a total of 4,488 for the year.

Number of Days Available (January - June)		181	
Less:			
Weekends	52		
Holidays	3		
Weather Days	34		
		89	
Number of Flying Days Available First Training Cycle			92
Number of Days Available (July - December)		184	
Less:			
Weekends	43		
Holidays	6		
Weather Days	23		
		72	
Number of Flying Days Available Second Training Cycle			112
Number of Flying Days Available Both Training Cycles			204

Figure 1

Available Flying Days

Number of Aircraft Assigned		24
Less:		
NORM G[a]	24%[c] = 5.76	
NORS G[b]	5%[c] = 1.20	
		6.96
	Flyable Aircraft	17.04
Flyable Aircraft		
Less:		
Non Mission Capable Aircraft	2%[c] = .34	
		.34
	Mission Capable Aircraft	16.70
Mission Capable Aircraft		
Less:		
Load Crew Training	4%[c] = .96	
QC Inspections	10%[d] = .114	
		1.07
	Available Flyable Aircraft per Day	15.63
Gross Sorties per Day = (Sortie Rate)(Available Aircraft)		
= (1.446)(15.63) =		22.6
Less:		
Non Delivered Aircraft	2%[c] = .45	
		.45
Net Sorties Available per Day for Planning		22.15

Figure 2

Available Sorties per Day

a. Aircraft grounded for maintenance.
b. Aircraft grounded for supply.
c. These factors are based on programmed maintenance data and should be verified with a unit's historical records.
d. QC Aircraft/Day = $\frac{\text{(Possessed Aircraft/Mo)(QC Rate)}}{\text{Duty Days/Mo}} = \frac{(24)(.10)}{21} = .114$

The next constraint is based on the total number of each sortie type which can be supported with available resources. The restriction could be due to the availability of training ordnance or training areas. This constraint does not apply to collateral sorties. Table 3, page 9, shows the relationship of collateral sorties to GCC sorties. From this relationship it can be determined that the minimum number of collateral sorties for planning would be 222 (six sorties per pilot). The maximum number of collateral sorties for planning would be 222 plus ten percent of the total number of GCC sorties flown.

The next step is to develop a list of constraints based on current training guidelines. By combining the requirements from applicable training directives, the commander's direction, and research of historical records, tables can be set up to identify both minimum and maximum sortie constraints. Table 9 shows the maximum sortie constraints and Table 10 shows the minimum sortie constraints for Level C. Each unit would need to develop similar tables based on their unique situations for each level of training.

Table 9

Maximum CT Sortie Requirements

Status	WD	SAT	MAV	ACBT	SAR	NIGHT	TOTAL
MR EXP	12	13	10	10	8	11	76
MR INEXP	14	20	12	12	10	15	97
MS	6	10	6	6	5	6	39

Notes.

1. MR staff flies at ninety percent of MR EXP level.
2. CT sorties for IQT/MQT pilots will be a prorated share of the Level A requirements.

Table 10

Minimum CT Sortie Requirements

Status	WD	SAT	MAV	ACBT	SAR	Night	Total
MR EXP	5	5	3	4	6	4	64
MR INEXP	7	4	4	6	6	4	83
MS	2	2	2	2	2	2	30

Notes.

1. MR staff flies at ninety percent of MR EXP level.
2. CT sorties for IQT/MQT pilots will be a prorated share of the Level A requirements.

The final area of concern is the number of sorties each pilot needs to maintain a given level of proficiency based on his own abilities. To determine the relative proficiency of each pilot a standardized program should be employed to ensure uniform results. Once the pilots are ranked from top to bottom, it is possible to develop and use a simple modification of Table 8, page 22, to provide additional sorties to those pilots with lower proficiency levels. Table 11 is an example of a simple program to allocate additional sorties to the lower ranking pilots. The unit is divided into five groups. The highest group flies at the minimum sortie rate while the lower groups gain additional sorties. The determination of the number of sorties which each group should gain can be determined from historical data in the squadron. For this evaluation, each of the groups will be given one additional sortie.* From Table 10 an experienced MR pilot in

*The selection of additional sorties given to each group should provide a stepped increase which will not result in the maximum sortie constraint being exceeded.

group I would get a minimum of five WD sorties and an inexperienced pilot in this same group would get seven WD sorties. In group II an experienced pilot would get six WD sorties (five sorties from Table 10 plus one sortie from Table 11) and an inexperienced pilot would get eight WD sorties (seven sorties from Table 10 plus one sortie from Table 11). This allocation process provides priority for inexperienced pilots.

Table 11

Minimum Sortie Adjustment Factors

Group	Sortie Rate
I	Minimum
II	Minimum + 1
III	Minimum + 2
IV	Minimum + 3
V	Minimum + 4

In addition to the maximum and minimum constraints, it is possible to simply set a specific level of sorties to be flown by letting the sortie type equal a fixed number (i.e., WD = 12). If the total of two sortie types is to remain constant an inverse relationship must be established (i.e., WD + SAT = 34). If desired, a given sortie type can be weighted relative to another type by stating the desired ratio (i.e., WD = 2SAT).

Linear Equations and Inequalities

In this section the foundation on which the linear programming model is based is developed. The objective statement, the constraints on the number of each type sortie, and constraints for a representative sample of pilots are developed.

The goal of the scheduler is to maximize the unit's combat readiness by optimizing the allocation of sorties so that no resources will be wasted. To meet this goal, the constraints developed for each pilot will provide a means by which sortie allocation can be efficiently accomplished. The objective function then becomes to minimize the use of resources. The objective function can be expressed as:

$$\text{Minimize } Z = X0101+X0102+X0103+ \ldots +X3705+X3706+X3707$$

The next area of concern is the development of constraints for each sortie type. This would normally be based on local conditions as discussed in the section on constraints. However, since this is not realistic with the imaginary squadron, the constraints were developed using Table 9, page 26, and Table 7, page 21. The results are summarized in Table 12.

From Table 12, the following constraints can be established for each type sortie:

$$
\begin{array}{ll}
(1) & X0101+X0201+X0301+ \ldots +X3501+X3601+X3701 \leq 462 \\
(2) & X0102+X0202+X0302+ \ldots +X3502+X3602+X3702 \leq 551 \\
(3) & X0103+X0203+X0303+ \ldots +X3503+X3603+X3703 \leq 362 \\
(4) & X0104+X0204+X0304+ \ldots +X3504+X3604+X3704 \leq 357 \\
(5) & X0105+X0205+X0305+ \ldots +X3505+X3605+X3705 \leq 313 \\
(6) & X0106+X0206+X0306+ \ldots +X3506+X3606+X3706 \leq 411 \\
(7) & X0107+X0207+X0307+ \ldots +X3507+X3607+X3707 \leq 522
\end{array}
$$

With the constraints established for the individual sortie types, the next consideration is to establish a series of constraints for a representative sample of the pilots typically found in a unit. To accomplish this task, examples will be provided using pilots P1, P2, P3, P16, and P17.

Table 12

Sortie Distribution

PILOT	WD	SAT	MAV	ACBT	SAR	NIGHT	COLS	TOTAL SORTIE
P1	6	10	6	6	5	6	0	39
P2	14	20	12	12	10	15	14	97
P3	12	13	10	10	8	11	12	76
P4	14	20	12	12	10	15	14	97
P5	12	13	10	10	8	11	25	89
P6	12	13	10	10	8	11	12	76
P7	12	13	10	10	8	11	12	76
P8	6	10	6	6	5	6	0	39
P9	12	13	10	10	8	11	25	89
P10	14	20	12	12	10	15	14	97
P11	14	20	12	12	10	15	14	97
P12	14	20	12	12	10	15	14	97
P13	11	12	9	7	7	10	25	81
P14	12	13	10	10	8	11	12	76
P15	14	20	12	12	10	15	14	97
P16	11	12	9	7	7	10	25	81
P17	13	7	5	6	8	14	18	61
P18	12	13	10	10	8	11	12	76
P19	14	20	12	12	10	15	14	97
P20	14	20	12	12	10	15	14	97
P21	11	12	9	7	8	10	9	65
P22	13	7	5	6	8	4	18	61
P23	12	13	10	10	8	11	25	89
P24	14	20	12	12	10	15	14	97
P25	14	20	12	12	10	15	14	97
P26	14	20	12	12	10	15	14	97
P27	6	10	6	6	5	6	0	39
P28	14	20	12	12	10	15	14	97
P29	14	20	12	12	10	15	14	97
P30	15	10	6	6	8	3	16	64
P31	12	13	10	10	8	11	12	76
P32	14	20	12	12	10	15	14	97
P33	12	13	10	10	8	11	12	76
P34	13	7	5	6	8	4	8	51
P35	16	12	7	7	8	3	9	62
P36	11	12	9	7	7	10	25	81
P37	14	20	12	12	10	15	14	97
TOTALS	462	551	362	357	313	411	522	2,978

Pilot P1 is an MS staff pilot. The constraints applicable to P1 are:

(8) X0101+X0102+X0103+X0104+X0105+X0106+X0107 $\leq$ 39
(9) X0101+X0102+X0103+X0104+X0105+X0106+X0107 $\geq$ 30
(10) X0101 $\leq$ 6
(11) X0101 $\geq$ 2
(12) X0102 $\leq$ 10
(13) X0102 $\geq$ 2
(14) X0103 $\leq$ 6
(15) X0103 $\geq$ 2
(16) X0104 $\leq$ 6
(17) X0104 $\geq$ 2
(18) X0105 $\leq$ 5
(19) X0105 $\geq$ 2
(20) X0106 $\leq$ 6
(21) X0106 $\geq$ 2
(22) X0107 $\leq$ 9
(23) X0107 $\geq$ 0

Pilot P2 is an inexperienced MR pilot. The following constraints apply:

(24) X0201+X0202+X0203+X0204+X0205+X0206+X0207 $\leq$ 97
(25) X0201+X0202+X0203+X0204+X0205+X0206+X0207 $\geq$ 83
(26) X0201 $\leq$ 14
(27) X0201 $\geq$ 8
(28) X0202 $\leq$ 20
(29) X0202 $\geq$ 15
(30) X0203 $\leq$ 12
(31) X0203 $\geq$ 8
(32) X0204 $\leq$ 12
(33) X0204 $\geq$ 8
(34) X0205 $\leq$ 10
(35) X0205 $\geq$ 8
(36) X0206 $\leq$ 15
(37) X0206 $\geq$ 6
(38) X0207 $\leq$ 14
(39) X0207 $\geq$ 8

Pilot P3 is an experienced MR pilot. The following constraints apply:

(40) X0301+X0302+X0303+X0304+X0305+X0306+X0307 $\leq$ 76
(41) X0301+X0302+X0303+X0304+X0305+X0306+X0307 $\geq$ 64
(42) X0301 $\leq$ 12
(43) X0301 $\geq$ 7
(44) X0302 $\leq$ 13
(45) X0302 $\geq$ 7
(46) X0303 $\leq$ 10

(47) $X0303 \geq 6$
(48) $X0304 \leq 10$
(49) $X0304 \geq 6$
(50) $X0305 \leq 8$
(51) $X0305 \geq 4$
(52) $X0306 \leq 11$
(53) $X0306 \geq 6$
(54) $X0307 \leq 12$
(55) $X0307 \geq 6$

For an experienced MR IP line 40 would be modified to indicate ≤ 89, line 41 would be changed to ≤ 77, line 54 would become ≤ 25, and line 55 would be ≥ 19.

Pilot P16 is an MR staff IP. The constraints which apply are:

(56) $X1601+X1602+X1603+X1604+X1605+X1606+X1607 \leq 81$
(57) $X1601+X1602+X1603+X1604+X1605+X1606+X1607 \geq 56$
(58) $X1601 \leq 11$
(59) $X1601 \geq 6$
(60) $X1602 \leq 12$
(61) $X1602 \geq 7$
(62) $X1603 \leq 9$
(63) $X1603 \geq 5$
(64) $X1604 \leq 7$
(65) $X1604 \geq 4$
(66) $X1605 \leq 7$
(67) $X1605 \geq 5$
(68) $X1606 \leq 10$
(69) $X1606 \geq 5$
(70) $X1607 \leq 25$
(71) $X1607 \geq 19$

The last example is pilot P17 who represents a new unit pilot who has completed IQT and MQT in four months and is required to accomplish a prorated share (one-third) of Level A CT sorties. The appropriate constraints are:

(72) $X1701+X1702+X1703+X1704+X1705+X1706+X1707 \leq 61$
(73) $X1701+X1702+X1703+X1704+X1705+X1706+X1707 \geq 49$
(74) $X1701 \leq 13$
(75) $X1701 \geq 10$
(76) $X1702 \leq 7$
(77) $X1702 \geq 4$
(78) $X1703 \leq 5$
(79) $X1703 \geq 3$
(80) $X1704 \leq 6$
(81) $X1704 \geq 6$

(82) $X1705 \leq 8$
(83) $X1705 \geq 3$
(84) $X1706 \leq 4$
(85) $X1706 \geq 2$
(86) $X1707 \leq 18$
(87) $X1707 \geq 12$

With a mathematical model developed for the imaginary squadron, the data can be translated into a format to be processed by a computer using an existing program to solve linear programming models. The computer solution represents a feasible semiannual sortie allocation.* The flexibility and utility of this scheduling technique will be evaluated in the next chapter.

*The computer solution derived for this model was obtained using a Control Data Corporation (CDC) model 6500 computer and the CDC APEX III program.

Chapter III

PROGRAM AND SOLUTION

This chapter is divided into two sections. The first section pertains to the computer program created for this particular research. The second section relates to the solution generated for the mathematical model developed for the imaginary A-7D squadron used as the data base for the problem.

Computer Program

In Chapter II a data base was established and used to develop an LP model. The next step was to write a computer program to simplify transforming the data base into an input for a computer program capable of solving LP problems. The program written for this purpose is listed in Appendix D.

Prior to explaining how the program works it will be necessary to explain some of the terminology used and the arrays or matrixes employed to hold data for processing. To familiarize the reader with the terminology the following definitions are offered:

Terminology	Meaning
P1	A matrix used to hold the input category for each pilot.
P2	A matrix used to hold ranking data for each pilot for each type sortie.
P3	A matrix used to hold total and sortie type maximums and minimums for each pilot (a row from Dimension Table.

RNKRNK	A matrix for holding the pilot's ranking in rank order for each sortie type. For example, if pilot X is ranked first in sortie type J then RNKRNK (1,J)=X.
CUTPER	An array which holds the percentages used to establish the group a pilot would fall into (see Table 8, page 22). Current values are .10, .30, .70, and .90.
CUTPT	An array which holds the numerical cut point determined from the total number of pilots entered and the percentages set in CUTPER.
DIMENSION TABLE	A matrix which holds values for each pilot category entry (currently 21). The values are maximums and minimums for TOTAL, WD, SAT, MAV, ACBT, SAR, NIGHT, and COLS. The columns with negative values reflect variable quantities set by the pilot's ranking in an event. The minus sign is a device used in the computer program to determine if the entry has a fixed or variable value and should not be construed to mean the actual value is negative.
FIXED SET	A value determined by the sign of column in DIMENSION TABLE. The value is TRUE if the sign is positive and FALSE if the sign is negative.
MAXFLT	An array which holds maximum allowed total sorties by sortie type.
RESPNS	An array used to hold input data moved to P1 and P2.
RESPNS(1)	Pilot number.
RESPNS(2)	Training category.
RESPNS(3)	Post training category.
RESPNS(4)	Months to complete training.
RESPNS(5)	Training status after training.
RESPNS(6)	Pilot status.
RESPNS(7)	IP status.
RESPNS(8)	Experience level.
RESPNS(9)	GCC level.
RESPNS(10)	Pilot rank (1).
TOTPLT	Total number of pilots.

MAXPLT	Maximum number of pilots for the program (currently 50).
PNMBR	Pilot number.
TNGCAT	Training category
POSTCT	Post training category (MR or MS).
CATGRY	Category (Primary or Staff).
EXPER	Experience level.
STATUS	Pilot mission status (MR or MS).
ENTRY	Row of DIMENSION TABLE.
POINT	Column to be entered in the DIMENSION TABLE.
BASE	Absolute value of entry in POINT.
BUMP	Amount by which BASE is to be increased.
RERANK	A subroutine used to rerank pilots based on the limitation that each pilot must be allocated at least as many sorties as the next pilot ranked lower in order. Pilots who would violate this constraint are removed from ranking.
RANK	A matrix used to hold initial pilot ranking by type sortie.
RANK(2)	A matrix used to hold pilots after reranking.
MAX	A matrix which holds modified rows of the DIMENSION TABLE.
MAXP	A column in MAX matrix which contains the maximum sortie constraints.
MINP	A column in MAX matrix which contains the minimum sortie constraints.
CARDS	A subroutine used to generate an output format suitable for input into the CDC APEX III program.
CHRANK	A subroutine used to check the ranks input to ensure they do not exceed number of total pilots or repeat.

The computer program used in this research depends on a simple matrix made up of the upper and lower bounds for each of the different

	MAX SORTIE	MIN SORTIE	MAX WD	MIN WD	MAX SAT	MIN SAT	MAX MAV	MIN MAV	MAX ACBT	MIN ACBT	MAX SAR	MIN SAR	MAX NIGHT	MIN NIGHT	MAX COLS	MIN COLS
1	55	46	8,	-4,	9,	-5,	7,	-3,	6,	-2,	5,	-1,	10,	5,	20,	15
2	72	72	10,	-6,	12,	-7,	7,	-3,	6,	-2,	9,	-5,	7,	5,	21,	16
3	81	75	11,	-6,	12,	-5,	9,	-5,	7,	-2,	9,	-5,	10,	5,	22,	17
4	42	33	8,	-4,	9,	-5,	7,	-3,	6,	-2,	5,	-1,	6,	2,	9,	6
5	56	50	10,	-6,	12,	-7,	7,	-3,	6,	-2,	9,	-5,	7,	5,	10,	6
6	65	59	11,	-6,	12,	-5,	9,	-5,	7,	-2,	9,	-5,	10,	5,	11,	9
7	39	30	6,	2,	10,	2,	6,	2,	6,	2,	5,	2,	4,	2,	9,	6
8	50	40	9,	-5,	9,	-5,	7,	-3,	6,	-0,	6,	-2,	6,	2,	10,	9
9	61	50	12,	-8,	12,	-8,	8,	-4,	6,	-2,	8,	-4,	6,	2,	11,	10
X	76	69	12,	-7,	13,	-8,	10,	-6,	8,	-4,	11,	-7,	11,	6,	2,	10
1	59	49	9,	-5,	9,	-5,	7,	-3,	6,	-0,	6,	-2,	6,	2,	25,	19
2	70	59	12,	-8,	12,	-8,	8,	-4,	6,	-2,	8,	-4,	6,	2,	25,	19
3	89	77	12,	-7,	13,	-8,	10,	-6,	8,	-4,	11,	-7,	11,	6,	25,	19
4	50	36	10,	-6,	12,	-8,	6,	-2,	6,	-0,	6,	-2,	6,	2,	10,	4
5	71	59	10,	-6,	13,	-8,	10,	-6,	8,	-4,	10,	-6,	6,	6,	12,	6
6	97	84	16,	-12,	18,	-13,	12,	-8,	10,	-6,	12,	-8,	15,	6,	13,	8
7	39	30	6,	2,	10,	2,	6,	2,	6,	2,	5,	2,	4,	2,	9,	6
8	69	50	17,	11,	13,	10,	8,	6,	8,	5,	6,	3,	4,	2,	14,	8
9	66	50	16,	10,	12,	9,	7,	5,	7,	4,	6,	3,	3,	2,	13,	9
X	62	60	15,	9,	10,	7,	6,	4,	6,	3,	6,	3,	3,	2,	16,	10
1	57	45	13,	10,	7,	4,	5,	3,	6,	6,	6,	3,	4,	2,	18,	12

Figure 3

Dimension Table

TABLE ENTRY	TNG CTGRY	NEXT STATUS	MONTHS TO COMP	PILOT CTGRY	PILOT STATUS	IP	EXPER	GCC LEVEL
1	CT			STAFF	MR	YES	EXP	A
2	CT			STAFF	MR	YES	EXP	B
3	CT			STAFF	MR	YES	EXP	C
4	CT			STAFF	MR	NO	EXP	A
5	CT			STAFF	MR	NO	EXP	B
6	CT			STAFF	MR	NO	EXP	C
7	CT			STAFF	MS	NO	EXP	
8	CT			PRIM	MR	YES	EXP	A
9	CT			PRIM	MR	YES	EXP	B
10	CT			PRIM	MR	YES	EXP	C
11	CT			PRIM	MR	NO	EXP	A
12	CT			PRIM	MR	NO	EXP	B
13	CT			PRIM	MR	NO	EXP	C
14	CT			PRIM	MR	NO	INEXP	A
15	CT			PRIM	MR	NO	INEXP	B
16	CT			PRIM	MR	NO	INEXP	C
17	IQT/MQT	MS						
18	IQT/MQT	MR	1					
19	IQT/MQT	MR	2					
20	IQT/MQT	MR	3					
21	IQT/MQT	MR	4					

Figure 4

Dimension Table Key

combinations possible for a squadron assigned to maintain GCC Level C and both NIGHT and SAR capabilities. This matrix is illustrated in Figure 3. Figure 4 shows a key to determine which rows of the matrix relate to which pilot characteristics. As training directives or local standards change, the only action required to update the program is to change the appropriate entry in the matrix to correspond to the new guidance.

Figure 5 illustrates the logic flow within the computer program. The required input data is requested by the program through a series of questions. The actual input data is checked and an error message printed when a discrepancy is noted. As the data is read into the program it is stored in various arrays or matrixes and then processed as required.

The program establishes the sizes of the pilot groups (I, II, III, IV, or V) based on cutpoints which are computed using preprogrammed percentages and the total number of pilots entered into the program. The size of the groups can be altered by changing the percentages stored in CUTPER.

Based on the inputs the program selects the appropriate row from the Dimension Table and saves the information for each pilot. Based on the cutpoints the columns of the Dimension Table that are variable , are adjusted, and the results are again stored. Next, the pilots are reranked by a process whereby the maximum by sortie type of each pilot is compared with the minimum of the next lower pilot. If the lower pilot's minimum is larger than the first pilot's maximum the lower pilot is given a ranking of "0." This results in spaces in the ranking sequence which need to be corrected (i.e., 1, 0, 3, 4, 0, 6).

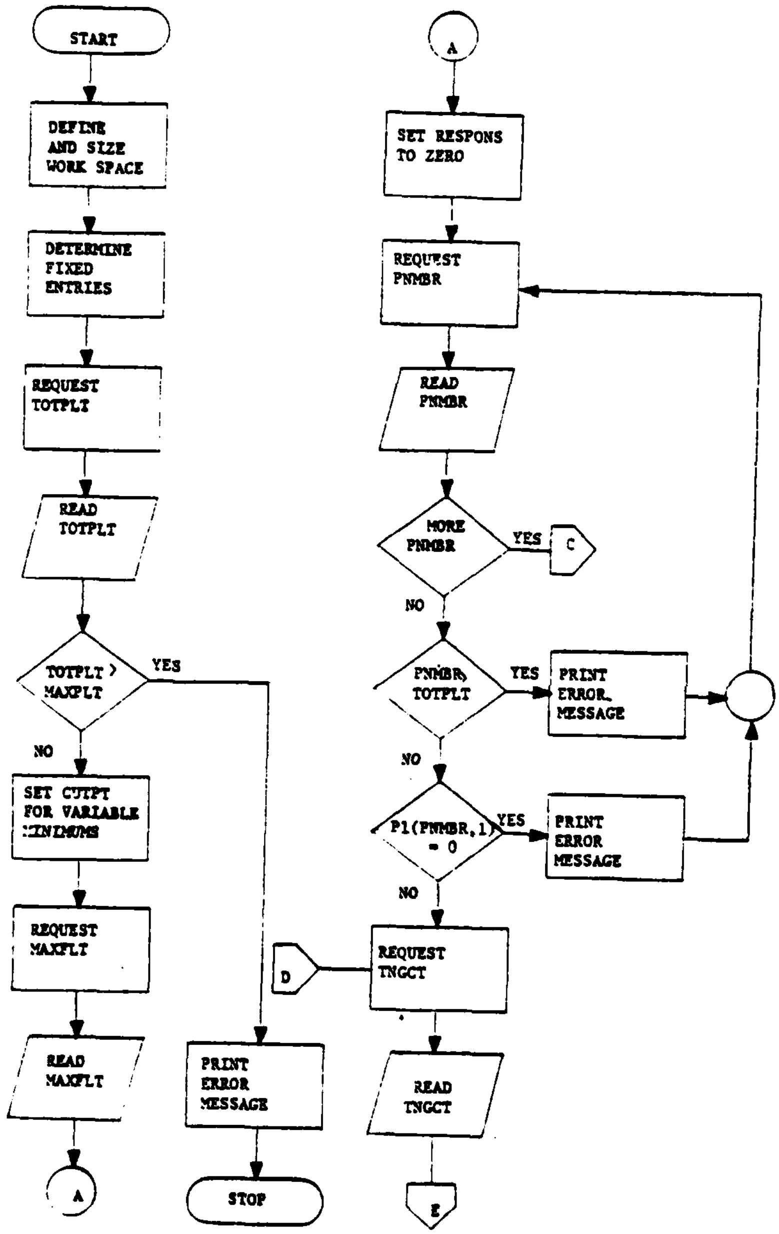

Figure 5

Flow Chart

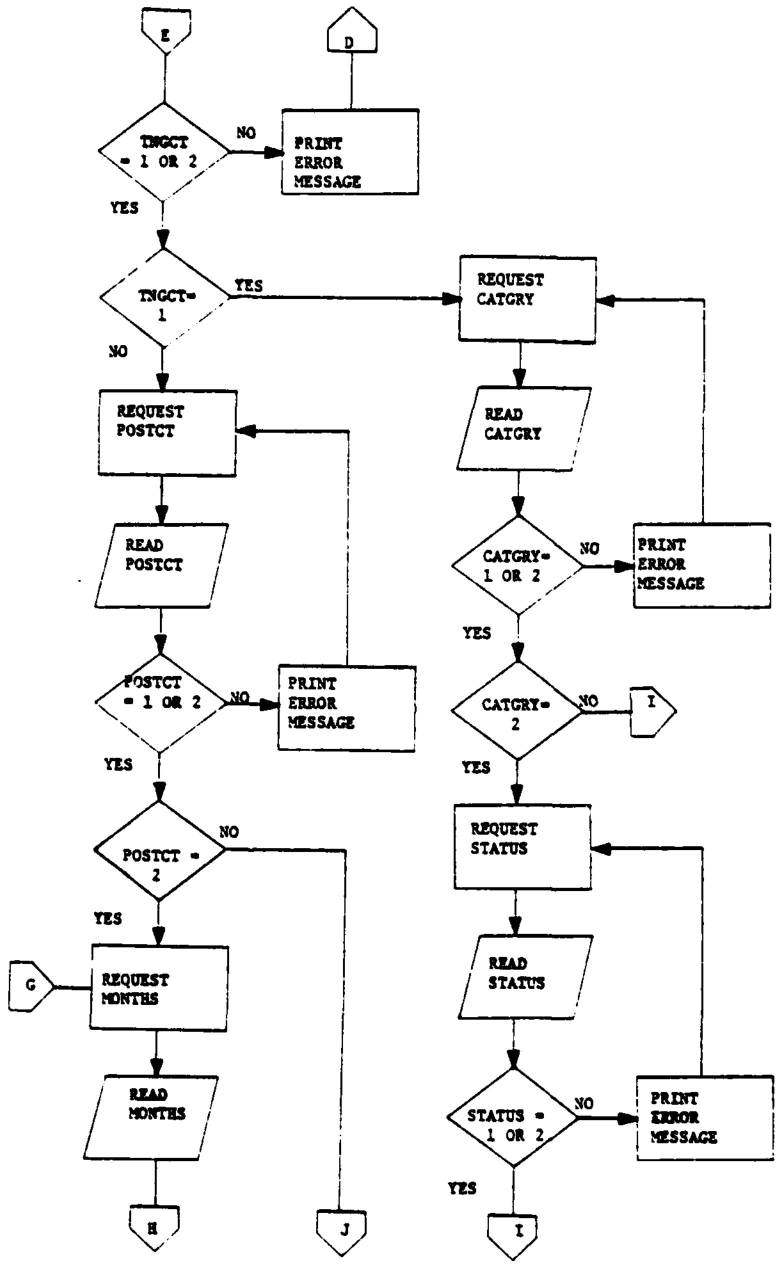

Figure 5 (Continued)

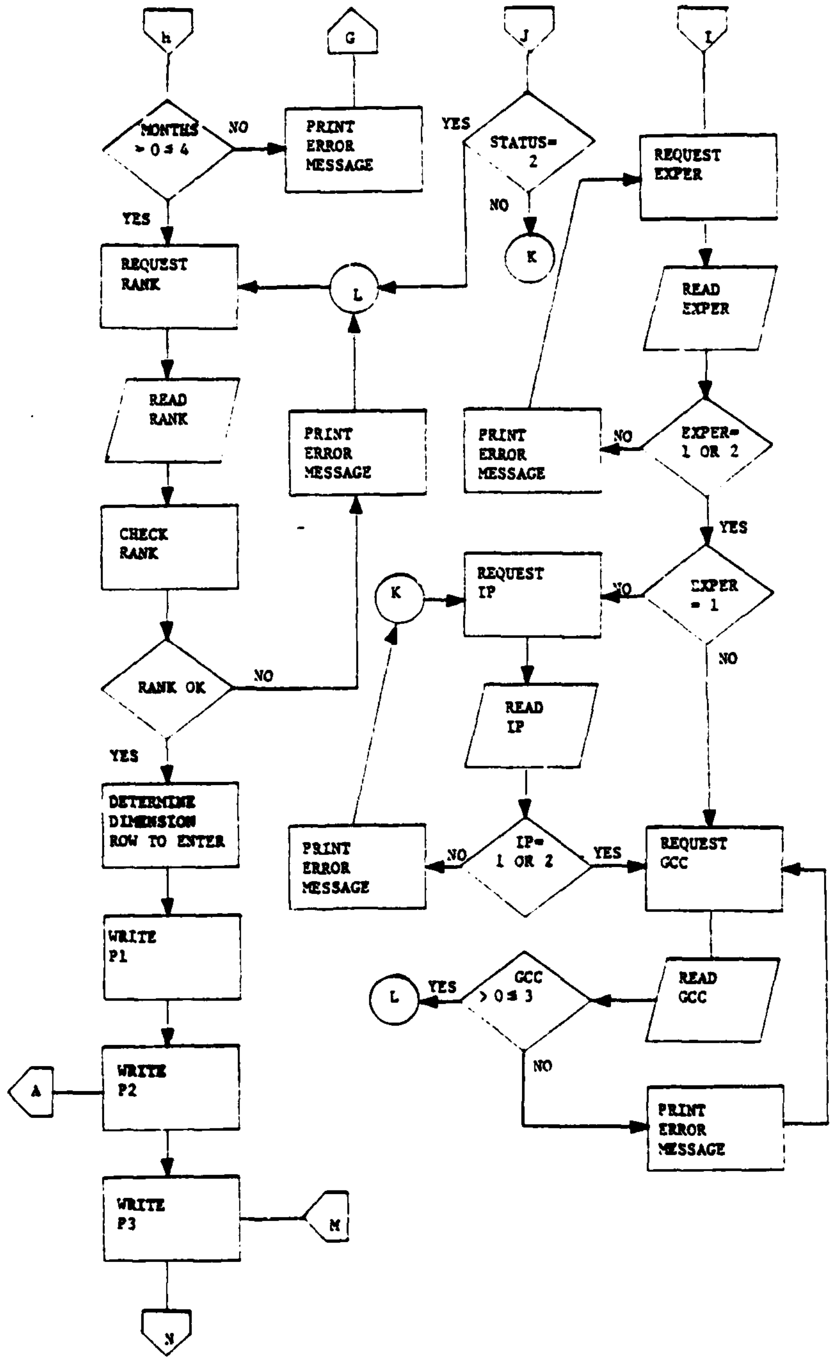

Figure 5 (Continued)

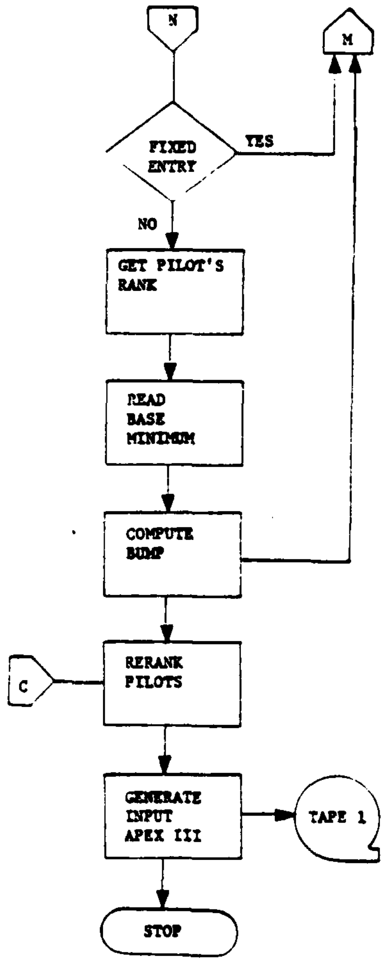

Figure 5 (Continued)

The nonzero entries are renumbered in sequence and the zero entries moved to the end of the matrix (i.e., 1, 2, 3, 4, 0, 0). This process was used to establish the constraint that a pilot should fly fewer sorties than the next lower ranked pilot unless this condition is not feasible due to other considerations (assignment of different GCC levels, mission status, or training category).

The final step in the program is to convert the input data into the proper format for the software package used (in this instance the CDC APEX III package).* The CARDS subroutine accomplishes this task by reading the processed data and generating an output in the general format depicted in Figure 6 on page 45. If a different input format is required for use with other linear programming software packages, the CARDS subroutine would have to be modified.

Further refinements are possible in the program by including additional error checks to make the system foolproof. Also, improvements would be made by adding loops to account for prorating pilots who are not available to fly during the entire training cycle or who are not tasked for both night and/or SAR requirements. Decision on what added capabilities are to be included in follow-on programs should be based on user needs and desires.

Although the original intent of developing the LP model was to minimize the sorties flown, the form of the objective function

---

*The CDC APEX III package is an optimization program which provides a flexible approach to solving linear or integer programming models. Both the input and output formats used are standardized throughout the computer industry for this type problem. The size of the LP problem which the system can solve is normally limited by the amount of central memory accessible (i.e., 8,190 maximum constraints and 32,760 variables).

```
NAME          PANNELL
ROWS
 L  TWD
 L  TSAT
 L  TMAV
 L  TACBT
 L  TSAR
 L  TNIGHT
 L  TCOLS
 DN TOTALS    TWD       1.   TSAT      1.
 DN TOTALS    TMAV      1.   TACBT     1.
 DN TOTALS    TSAR      1.   TNIGHT    1.
 DN TOTALS    TCOLS     1.
 L  P01
 L  P02
COLUMNS
    P01WD     TWD        1.   P01       1.
    P01SAT    TSAT       1.   P01       1.
    P01MAV    TMAV       1.   P01       1.
    P01MAV    CO501MAV  -1.
    P01MAV    CO103MAV   1.
    P01ACBT   TACBT      1.   P01       1.
    P01SAR    TSAR       1.   P01       1.
    P01NIGHT  TNIGHT     1.   P01       1.
    P01COLS   TCOLS      1.   P01       1.
    P02WD     TWD        1.   P02       1.
    P02WD     CO502WD   -1.
    P02SAT    TSAT       1.   P02       1.
    P02SAT    CO502SAT  -1.
    P02MAV    TMAV       1.   P02       1.
    P02MAV    CO302MAV  -1.
    P02ACBT   TACBT      1.   P02       1.
    P02ACBT   CO402ACBT -1.
    P02SAR    TSAR       1.   P02       1.
    P02SAR    CO302SAR  -1.
    P02NIGHT  TNIGHT     1.   P02       1.
    P02COLS   TCOLS      1.   P02       1.
RHS
    RHS       TWD       100
    RHS       TSAT      100
    RHS       TMAV      100
    RHS       TACBT     100
    RHS       TSAR      100
    RHS       TNIGHT    100
    RHS       TCOLS     100
    RHS       P01        65
    RHS       P02        97
RANGES
    RANGES    P01         8
    RANGES    P02        13
BOUNDS
 UI BOUNDS    P01WD      11
 LI BOUNDS    P01WD      10
 UI BOUNDS    P01SAT     12
 LI BOUNDS    P01SAT      9
 UI BOUNDS    P01MAV      4
 LI BOUNDS    P01MAV      7
 UI BOUNDS    P01ACBT     7
 LI BOUNDS    P01ACBT     6
 UI BOUNDS    P01SAR      4
 LI BOUNDS    P01SAR      9
 UI BOUNDS    P01NIGHT   10
 LI BOUNDS    P01NIGHT    5
 UI BOUNDS    P01COLS    11
 LI BOUNDS    P01COLS     9
 UI BOUNDS    P02WD      16
 LI BOUNDS    P02WD      13
 UI BOUNDS    P02SAT     18
 LI BOUNDS    P02SAT     14
 UI BOUNDS    P02MAV     12
 LI BOUNDS    P02MAV     12
 UI BOUNDS    P02ACBT    12
 LI BOUNDS    P02ACBT     4
 UI BOUNDS    P02SAR     10
 LI BOUNDS    P02SAR      9
```

Figure 6

LP Input

Note. Input data is divided into five sections: ROWS, COLUMNS, RHS, RANGES, and BOUNDS. The ROWS section names each row and shows if the ROW ACTIVITY is to be less than, greater than, or equal to the RHS. The COLUMNS section names each column and indicates the nonzero quantities. The RHS section names the right hand side(s) and shows the nonzero quantities. The RANGES section specifies the difference between the upper and lower limits of ROW ACTIVITY. The BOUNDS section specifies the upper and lower limits for the columns.

makes it possible to run both a maximum and minimum solution to provide the scheduler with more information and a better basis for decision making. The next section provides a discussion of the computer solutions and the information available.

Computer Solution

The computer solution consists of two divisions, the first containing the minimum solution and the second containing the maximum solution. The minimum and maximum divisions are further divided into two sections. The first section, labeled CONSTRAINTS, depicts information on the rows of the solution matrix (listing of total sorties by type and by pilot). The second section, labeled COLUMNS, depicts the information on the columns of the solution matrix (listing by pilot of the number of each type sortie).

The CONSTRAINTS section is further divided into nine columns. These columns are labeled NUMBER, NAME, TYPE, STATUS, ROW ACTIVITY, SLACK, RHS LOWER, RHS UPPER, and MARGINAL.

NUMBER. The entries under this column are all integers. The integers represent the input order for the row.

NAME. The alphanumerics in this column are the row names. The names may be in one of three forms:

TWD	(Total WD sorties)
P01	(Total sorties for pilot 1)
C1416WD	(Constraint on relationship between pilot 14 and pilot 16 WD sorties)

TYPE. Entries in this column indicate the nature of the relationship involved in the LP model. The possible entires include:

EQ	(Equals)
GE	(Greater than or equal)
LE	(Less than or equal)

FR (Free range from $-\infty$ to $+\infty$)

** (An alternate optimal solution exists)

If a row is ranged a B will precede the above designators.*

STATUS. Indicates the basis status of the slack variable.** Entries are:

BINDING (Either there is no slack, or this is a basis status of nonbasic or nonbasic at a bound)

SLACK (There is slack or unused resources. This is a basis status of basic)

ROW ACTIVITY. The sum of the row activity (solution).

SLACK. The value of the difference between the right hand side (RHS) value input and the current ROW ACTIVITY (solution).

RHS LOWER. The minimum value the row sum can have.

RHS UPPER. The maximum value the row sum can have.

---

*Ranging applies to row (constraints) of the problem and is a positive number which sets the allowable deviation from the RHS value. It serves the same purpose for rows that upper and lower bounds serve for columns.

**Using a simplex tableau made up of a system of m equations and n variables, where m is less than n, let the excess variables (n-m) be assigned a value of zero. Then the remaining m equations in m variables have a unique solution such that:

(1) The variables (n-m) assigned a zero value are said to be "nonbasic."

(2) The remaining variables (m) are called "basic."

(3) The solution to the tableau is called a "basic solution." (5: 227-228)

MARGINAL. The shadow price of the row. The value indicates the change in the objective function for a change of one unit in the row. The sign of the MARGINAL value indicates if the objective function will increase or decrease when the row is changed by one unit. If the sign is positive the objective function will worsen and if negative the objective function will be improved.

If the ROW ACTIVITY is less than the RHS LOWER value or greater than the RHS UPPER value, the word INFEASIBLE will be printed on the extreme right hand side of the solution indicating a shortage of sorties. Either additional sorties will have to be made available or a less than optimal sortie allocation will have to be accepted. If the MARGINAL entry is nonzero in value and has an improper sign for the row TYPE and STATUS, the word NONOPTIMAL will be printed on the extreme right hand side of the solution indicating a better solution would be possible if the appropriate bound were changed. No action is required.

The COLUMNS section is divided into nine columns also. These columns are labeled NUMBER, NAME, TYPE, STATUS, COL ACTIVITY, OBJ COEF, BND LOWER, BND UPPER, and MARGINAL.

NUMBER. The integers in this column are the input order of the column entries.

NAME. The alphanumerics in this column are the names given to the columns. The names are in the form

P01WD (WD sorties allocated to pilot 1)

TYPE. Entries in this column indicate the column relationships. Possible entries include:

PL	(Plus variable)
MI	(Minus variable)
FX	(Fixed variable)
FR	(Free variable)
BV	(Bivalent variable; can be either 1 or 0)
INT	(Integer variable)
**	(Indicates other optimal solutions exist)

For ranged variables a B will precede the above designators.

STATUS. Entries in this column show the basis status of the column. The status can be:

ACTIVE	(Column is basic)
UPPER	(Nonbasic variable at its greatest value)
LOWER	(Nonbasic variable at its smallest value)

COL ACTIVITY. The value in this column is the column activity level or current solution.

OBJ COEF. Entries in this column give the value of the objective column coefficient. For this solution the value will always be one.

BND LOWER. The smallest value the variable can have.

BND UPPER. The largest value the variable can have.

MARGINAL. The reduced or shadow cost of the variable.

If the value of the COL ACTIVITY is less than BND LOWER or more than BND UPPER the word INFEASIBLE will be printed on the extreme right hand side of the solution. If the MARGINAL value is nonzero and has an

improper sign for the column, the word NONOPTIMAL is printed on the extreme right hand side of the solution.

A review of some specific examples will help to explain how to interpret the data. To do this notional examples will be used for NUMBER entries 5(TSAR), 12(P04), and 48(C0932WD) of the CONSTRAINTS section and NUMBER entry 204(P30WD) of the COLUMNS section.

The original constraint for the total number of SAR sorties was X0105+X0205+X0305+ ... +X3505+X3605+X3705 $\leq$ 313. This condition is reflected in the entries in the nine columns of the CONSTRAINTS section as:

Column	Entry	Meaning
NUMBER	5	TSAR was input number five to program.
NAME	TSAR	Total SAR sorties.
TYPE	LE	Constraint is less than or equal relationship.
STATUS	SLACK	Row sum not equal to RHS UPPER value.
ROW ACTIVITY	355	Total SAR sorties needed for feasible solution.
SLACK	-42	ROW ACTIVITY exceeds RHS UPPER by 42 sorties. Need 42 more SAR sorties for a feasible solution.
RHS LOWER	-INF	Since no bound was specified a $-\infty$ lower limit is implied.
RHS UPPER	313	Initial SAR sorties for planning.
MARGINAL	.	If no value is entered the value is assumed to be zero. The shadow cost is zero.

The word INFEASIBLE printed at the right hand side indicates ROW ACTIVITY value is greater than RHS UPPER value. Forty-two more SAR sorties would be needed for the solution to be feasible.

The original constraints for the maximum and minimum number of sorties pilot 4 (P04) could fly were:

X0401+X0402+X0403+X0404+X0405+X0406+X0407 $\leq$ 97 and

X0401+X0402+X0403+X0404+X0405+X0406+X0407 $\geq$ 83.

These conditions are reflected in the entries in the nine columns of the CONSTRAINTS section as:

Column	Entry	Meaning
NUMBER	12	P04 was number twelve input to program.
NAME	P04	Total sorties for pilot 4 (P04).
TYPE	BLE	Relationship is a ranged less than or equal constraint.
STATUS	BINDING	Basis status at RHS LOWER value.
ROW ACTIVITY	83	Total sorties allocated to P04.
SLACK	14	Difference between RHS UPPER and ROW ACTIVITY values.
RHS LOWER	83	Minimum sorties for P04.
RHS UPPER	97	Maximum sorties for P04.
MARGINAL	-4	If the number of sorties allocated to P04 was increased the objective function value would increase by 4.

To understand the entries for C0932WD it is necessary to examine the ranking process and the constraint that a pilot should not get more sorties than the pilots ranked lower than him in that type of sortie. For the basic solution, the following conditions were formulated:

Pilot Number	WD Ranking	Lower-Upper Bounds
P09	3	7 - 12
P32	4	12 - 16

For the constraints to hold, if P09WD equaled 12 then P32WD would have to be 12 or more. The difference between P09WD and P32WD would be the slack. Since P09WD is required to be larger or equal to P32WD, the slack must have a negative sign. These conditions are reflected in the entries in the nine columns of the CONSTRAINTS section as:

Column	Entry	Meaning
NUMBER	48	Input was number 48 to program.
NAME	C0932WD	Constraint between P09WD (X0901) and P32WD (X3201).
TYPE	LE	P09WD $\leq$ P32WD.
STATUS	SLACK	There is a difference between P09WD and P32WD.
ROW ACTIVITY	-2	P09WD is 2 units less than P32WD.
SLACK	2	Difference between RHS UPPER and ROW ACTIVITY is 2.
RHS LOWER	-INF	Since no lower limit was stated, $-\infty$ is implied.
RHS UPPER	.	Since P09WD is not allowed to be greater than P32WD the maximum value is 0 when the two values are equal.
MARGINAL	.	The shadow value is 0.

From the COLUMNS section the value for P09WD is 11 and for P32WD is 13. Therefore, the slack between P09WD and P32WD is 2.

The final entry to be reviewed is the restriction on P30WD sorties. The original constraints were:

$$X3001 \leq 15$$

$$X3001 \geq 9$$

These conditions are reflected in the entries in the columns of the COLUMNS section as:

Column	Entry	Meaning
NUMBER	204	Input was number 204 to program.
NAME	P30WD	Total WD sorties for pilot 30 (P30).
TYPE	INT	Integer variable.
STATUS	**UPPER	Other optimal solutions exist. Solution is BND UPPER value.
COL ACTIVITY	15	Solution for number of WD sorties allocated to pilot P30.
OBJ COEF	1	Coefficients of WD variables are equal to 1.
BND LOWER	9	Minimum WD sorties for P30.
BND UPPER	15	Maximum WD sorties for P30.
MARGINAL	.	In the current solution there is no reduced costs for variable (X3001).

This chapter has presented an outline of the basic composition of the FORTRAN computer assisted scheduling program and the computer solution print-out. The intent was to familiarize the reader with how the system works and the information available. For a general guide on how to use the system see Appendix G.

Chapter IV

ANALYSIS AND CONCLUSIONS

Resource allocation problems lend themselves to mathematical optimization techniques. This is natural since there exists an objective or goal and various restrictions or constraints. There are both disadvantages and advantages to the application of mathematical techniques in assisting or accomplishing aircrew scheduling.

Disadvantages include the determination of optimality of the schedule generated and the formulation of the numerous constraints and decision variables. Another lesser difficulty could be an inability to quickly modify the basic computer program in the field to account for changes in scheduling priorities as they occur. This problem exists because there are no computer programmers readily available in the field to perform the required modifications. Probably the most limiting factor in the approach presented in this study is the need to rank pilots according to their individual proficiency in different types of sorties. My experience has been that pilots do not like to be ranked against their peers and would be concerned with the other possible uses of such rankings (job selection, OERs, etc.). Further limitations arise since objective measurement systems do not currently exist in some of the areas to provide a measure of individual pilot proficiency.*

---

*Development of objective measurements of training programs is a subject of continued interest of Headquarters TAC Standardization/Evaluation and is listed as a research topic in the 1979-80 volume of the Air University Compedium of Research Topics.

The advantages of this approach to resource allocation are considerable. Once the basic constraints are identified and expressed in mathematic relationships a linear model can be developed and solved by one of the many LP software packages which are readily available. Flexibility of the system depends primarily on the number of considerations taken into account when developing the basic program. The input program developed for this research clearly indicates the ease with which an interactive program can be produced which will be easy for any scheduler to employ without detailed training in computer languages. The ease with which various combinations can be generated and compared should lead to considerable time savings for the scheduler. Ultimately, the greatest advantage should be the efficient allocation of available training sorties to those who need them the most resulting in a unit with the highest overall proficiency or readiness.

The specific approach studied in this research should prove to be a valuable management tool. The approach can accurately project the training resources needed. It can be used to project requirements by total sorties, total sorties by type, and sorties both total and type for each pilot. In addition, by using both minimum and maximum solutions a range or "delta" for various sortie needs can be forecast. If this approach were combined with a system for prioritizing pilots for flight requirements based on qualification status, currency, quantity of sorties needed, and availability a very powerful computer assisted scheduling program could be generated.

Further research should be directed at the use of linear programming models in computer assisted scheduling modes. As the current

TAFTRAMS is changed from a batch system to an interactive system in the 1982 time frame the use of a system similar to the one developed in this research could be of considerable aid to the scheduler.* The next logical step would be to introduce the use of a goal programming approach into the scheduling process to allow for introduction of a priority goal system.

The current Burroughs Medium Computer system used by TAC was designed primarily for business applications. The system was not designed to perform high level arithmetic or scientific functions. However, the systems can perform these two functions when modified with a floating point adapter. This is a major drawback to implementing the program developed in this research due to the cost of the modification.

Another drawback to using the FORTRAN computer assisted scheduling program is the need for a FORTRAN compiler when using FORTRAN programs. This drawback can be overcome without any additional cost by using the available compilers and rewriting the program in the COBOL language or any other language compatible with the existing compilers.**

The availability of an LP software package which could be used in place of the CDC APEX III package is another area of concern. Burroughs markets a software package named TEMPO. This package is a

---

*Conversion of TAFTRAMS to an interactive AFORMS system in the 1982 time frame was confirmed as a goal in a conversation with Captain Andy Dorman from TAC DOOTR.

**A compiler is an input device for translating programming languages into a machine language used by the computer for processing.

mathematical programming system which provides a capability similar to the CDC APEX III system. The input and output formats used by both systems are essentially the same. It would take only minor modification to make the FORTRAN computer assisted scheduling program compatible with the Burroughs' TEMPO system.

The major factor remaining then is cost. There are at least four options which could be followed to allow the scheduler access to this type of scheduling assistance each with differing costs. The options are:

1. Modify all existing Burroughs medium systems with the floating point adapter and buy or lease the TEMPO package for each wing size unit.

2. Modify one system at Headquarters TAC, buy or lease the TEMPO package, and provide access to the units assigned to TAC.

3. Develop a suitable integer programming model using TAC resources and modify either one or all of the medium systems with floating point adapters.

4. Purchase a minicomputer for each wing size unit and develop a compatible integer programming software package.

To determine which option is most desirable in terms of a cost/benefit ratio additional analysis would be required at the time implementation of the program is contemplated.

The basic conclusion derived from this research is that while the application of LP models to aircrew scheduling can improve the efficiency of sortie allocation such a system cannot be currently implemented. Additional research will be required to determine the best

method to overcome the existing obstacles so that the benefits to be gained from this application can be realized.

Chapter V

SUMMARY AND RECOMMENDATIONS

The thesis of this research was that linear programming could be used to improve aircrew scheduling procedures by providing an efficient means of allocating available training resources to meet applicable training directives and the proficiency of individual pilots. To evaluate this thesis an imaginary A-7D squadron was established to provide the framework on which to build a mathematical model. The model was created using the general format applicable to linear programming models.

To simplify the transition from the linear programming model to a document which the scheduler could use for sortie allocation, a FORTRAN computer assisted scheduling program was written. This program was set up so that a detailed knowledge of computer programming was unnecessary. Indeed, all the scheduler is required to do is answer questions generated by the program and then tie the program to a computer software package for solving linear programming models.

Evaluation of the computer product indicated significant benefits to be gained in better use of available training resources. No apparent contradictions could be found with the computer product and applicable directives.

Research into the capabilities of the current computer capability possessed by TAC units indicates a degree of modification would

be needed before implementation of the program generated for this research could become a reality. However, the current Burroughs Medium System computer family can be used to perform the higher mathematics involved by addition of a floating point adapter. Furthermore, Burroughs has a current computer software package called TEMPO for the medium system computers which will provide the required LP model solving capability.

The feasibility of using linear programming and computer techniques to assist the scheduler in efficiently allocating training sorties has been adequately demonstrated. However, additional research will be involved before the system can be fielded. Additional work must be accomplished on developing meaningful programs to measure aircrew proficiency so that a suitable ability will exist to objectively rank pilots in the variety of sortie types flown. Also, research will be needed to determine if the cost/benefit ratio is great enough to justify the funds to support conversion of current systems to allow higher mathematical operations. If research into these two areas is positive, then actions should be taken to implement this or a similar follow-on program to assist the scheduler in using our ever dwindling training resources more efficiently.

APPENDIX A

APPENDIX A

DEFINITIONS AND ABBREVIATIONS*

Air-to-Air Refueling (AAR). An event requiring hookup and transfer of fuel between two aircraft in-flight.

Air Combat Maneuver (ACM). Coordinated application of BFM by two or more aircraft to achieve a simulated kill against one or more target aircraft from a preplanned and "canned" position.

Air Combat Tactics (ACT). Application of ACM skills to achieve a tactical air-to-air objective under realistic scenarios.

Air Combat Training (ACBT). A generic term which inclues BFM/DBFM, ACM/DACM, ACT/DACT, and DCM where tasked in GCC training.

Air Reserve Forces (ARF). Any of units assigned to the components of the United States Air Force Reserves.

Air Support Tactics (AST). Close air support and air support training missions flown against targets identified by the battlefield commander.

Air-to-Surface Training (A/S). Training which consists of weapons delivery and surface attack sorties.

Basic Fighter Maneuvers (BFM). Basic application of skills in roll, turn, and acceleration singularly or in combination toward one versus one aircraft positioning.

Collateral Sorties (COLS). Sorties in addition to GCC requirements programmed to account for non-effective sorties and training required by Air Force requirements.

Continuation Training (CT). Training flown by MR/MS aircrews to maintain proficiency and meet training requirements.

Dissimilar Air Combat Maneuvers (DACM). ACM flown against one or more aircraft of a different design or series.

Dissimilar Air Combat Tactics (DACT). ACT flown against one or more aggressor aircraft of a different design or series.

Dive Bomb (DB). Delivery of ordnance off an aircraft from a dive angle of thirty degrees or more.

Dissimilar Counter Maneuvering (DCM). BFM flown to negate an air-to-air attack and safely disengage.

Graduated Combat Capability (GCC). A three level concept of managing resources against training requirements.

Instructor Pilot (IP). A pilot selected because of his high experience level and mature judgement to train other pilots.

Initial Qualification Training (IQT). Training flown before a pilot takes his proficiency checkride and enters MQT.

Interdiction Tactics (IT). Tactical sorties flown on interdiction profiles emphasizing employment against preplanned targets.

Low Angle Bomb (LAB). Delivery of a high drag weapon from a dive angle of less than twenty degrees.

Low Angle Low Drag Bomb (LALD). Delivery of a low drag weapon with a dive angle between twenty and thirty degrees.

Low Angle Strafe (LAS). Delivery of 20/30 mm ordnance on a surface target with a dive angle of less than twenty degrees.

Mission Qualification Training (MQT). Training following IQT which prepares aircrews for their initial qualification checkride and entry into CT.

<u>Mission Ready (MR)</u>. Status of an aircrew who meets GCC training requirements. The aircrew could enter into combat without further training.

<u>Mission Support (MS)</u>. Status of an aircrew who flys the unit aircraft in support duties. An MS pilot requires further training prior to entry into combat.

<u>Search and Rescue (SAR)</u>. Locating and recovering downed aircrews in time of war.

<u>Sortie</u>. One flight from take-off to final landing.

<u>Standardization/Evaluation Flight Examiner (SEFE)</u>. An IP who is designated to perform aircrew flight evaluations in accordance with the Standardization/Evaluation Program.

<u>Visual Low Level Navigation</u>. A navigation flight flown at or below 1500 feet above the ground on a preplanned route.

<u>Weapons Delivery (WD)</u>. Expenditure of munitions against a surface target.

---

*The definitions in this glossary are extracted from TACM 51-50 and the United States Air Force Dictionary.

APPENDIX B

APPENDIX B

MATHEMATICAL OVERVIEW

To understand the procedures developed in Chapter II, a general knowledge of linear programming techniques is needed. To provide the basic level of information necessary, the basic concepts are reviewed in this appendix. In addition, an introduction is provided to both dynamic and goal programming.

Linear Programming

Linear programming is based on the assumption that a decision maker desires to either maximize something (to make a value as large as possible) or minimize something (to make a value as small as possible). (5:212) The something which is to be maximized or minimized is called the objective function. The objective function is made of two or more variables to which the decision maker can assign values. Variables which can be assigned values by the decision maker and which affect the objective are labeled structural or decision variables. A list of variables with assigned values is called a program or solution.

For the decision maker to develop an optimal program he must identify the relationship existing between the objective and the structural variables. In addition to the objective function, mathematical models are based on the assumption that the decision maker is faced with restrictions on the values which the structural variables can be assigned. These restrictions include limited resources, technical requirements, or other obligations.

Restrictions are included in mathematical models by introducing constraints. A constraint is a relationship that limits the values a structural variable can be assigned. Constraints can be expressed in terms of three propositions. The propositions are (1) equal to, (2) greater than, and (3) less than.

To understand how an optimal solution is obtained, one must know the difference between feasible, infeasible, and optimal programs. A feasible program is one which meets all of the constraints of the mathematical model, whereas an infeasible program violates one or more of the constraints. An optimal program is one which is feasible and either maximizes or minimizes the objective function.

Underlying linear programming is the proposition that the objective function and all the constraints are linear relations and that the structural variables are nonnegative. These considerations can be expressed mathematically as follows:

1. The objective function is expressed as

$$f(z) = a_1x_1+a_2x_2+a_3x_3+ \dots +a_nx_n$$

where $a_1, a_2, a_3, \dots, a_n$ are real-valued constants.

2. Each constraint is expressed as

$$b_1x_1+b_2x_2+b_3x_3+ \dots +b_nx_n = C, \text{ or}$$

$$b_1x_1+b_2x_2+b_3x_3+ \dots +b_nx_n \geq C, \text{ or}$$

$$b_1x_1+b_2x_2+b_3x_3+ \dots +b_nx_n \leq C,$$

where $b_1, b_2, b_3, \dots, b_n$ are real-valued constants.

3. The structural variables $x_1, x_2, x_3, \dots, x_n$ are real-valued variables. (2:1)

Simple linear programming models of two variables can be solved manually by using graphical techniques. Linear models which have more than two variables require using nongraphical techniques such as the simplex algorithm. The use of the simplex algorithm technique becomes very tedious as the number of variables increase. Computer manufacturers or company vendors offer computer programs (software) for solving linear programming models. The use of these programs facilitates the solution of linear models and provides the user a number of means for post-optimal solution analysis. (2:144) The ability to perform post-optimal solution analysis allows an evaluation of the effects of changes in any of the constraints which define the problem.

Dynamic Programming

Dynamic programming is a valuable technique when faced with multistage or time related decision processes (processes involving multiple interrelated choices). Multistage decision processes are thought of as being made up of policy choices, stages, states, and objectives. (5:Ch 10)

Policy Choice. A policy choice is a choice (decision) made at some point in a multistage decision process. Usually a policy choice is needed at each of the stages.

Stage. A stage is a set of feasible choices occurring at some point in a multistage decision process.

State. A state is a condition that influences a policy choice at a decision stage.

Objective. An objective is the goal to be attained by the policy choice selected at each stage of the decision process.

In general, dynamic programming may be useful in instances where linear programming models are not feasible. Dynamic algorithms can be developed and computerized for use in solving complex problems with a great number of variables. While this technique is beneficial in solving multistage decision processes, it is by no means a panacea for solving all very large problems. If there are too many state variables at each stage, the amount of computer memory required for storage becomes excessive. The end result is that even very large computers may be unable to accommodate the memory needs of some dynamic programming algorithms.

Goal Programming

Goal programming is gaining in popularity as a technique for solution of problems with competing objectives. It is a relatively recent method which takes into account trade-offs between possible goals or objectives for the decision maker. It is a modification of linear programming which takes advantage of the slack variables to free the decision maker from a one dimensional objective function.* It accomplishes this task by using the slack variables to minimize the deviations between goals that are set within the system of constraints for the problem.

The goals or objectives for the problem are stated and arranged in order of their priority. The algorithm used for the solution process successively seeks the achievement of these goals in priority, where the higher goals become constraints which must not be violated.

---

*A slack is a variable used to show how much of a given resource was not used in a solution.

Therefore, higher goals are satisfied at the expense of the lower priority goals. This approach will let the decision maker meet as many of his needs as is feasible under the conditions which prevail for the problem.

APPENDIX C

APPENDIX C

VARIABLE LISTING

To read Table 13, read down column one, labeled pilot, to the pilot number desired. Then to determine the variable designation for a specific type sortie move to the right along the same row to where it intersects with the desired column. For example, the variable representing the number of weapons delivery sorties flown by pilot 10 (P10) would be X1001.

TABLE 13

Variables

PILOT	WD (01)	SAT (02)	MAV (03)	ACBT (04)	SAR (05)	NIGHT (06)	COLS (07)
P1	X0101	X0102	X0103	X0104	X0105	X0106	X0107
P2	X0201	X0202	X0203	X0204	X0205	X0206	X0207
P3	X0301	X0302	X0303	X0304	X0305	X0306	X0307
P4	X0401	X0402	X0403	X0404	X0405	X0406	X0407
P5	X0501	X0502	X0503	X0504	X0505	X0506	X0507
P6	X0601	X0602	X0603	X0604	X0605	X0606	X0607
P7	X0701	X0702	X0703	X0704	X0705	X0706	X0707
P8	X0801	X0802	X0803	X0804	X0805	X0806	X0807
P9	X0901	X0902	X0903	X0904	X0905	X0906	X0907
P10	X1001	X1002	X1003	X1004	X1005	X1006	X1007
P11	X1101	X1102	X1103	X1104	X1105	X1106	X1107
P12	X1201	X1202	X1203	X1204	X1205	X1206	X1207
P13	X1301	X1302	X1303	X1304	X1305	X1306	X1307
P14	X1401	X1402	X1403	X1404	X1405	X1406	X1407
P15	X1501	X1502	X1503	X1504	X1505	X1506	X1507
P16	X1601	X1602	X1603	X1604	X1605	X1606	X1607
P17	X1701	X1702	X1703	X1704	X1705	X1706	X1707
P18	X1801	X1802	X1803	X1804	X1805	X1806	X1807
P19	X1901	X1902	X1903	X1904	X1905	X1906	X1907
P20	X2001	X2002	X2003	X2004	X2005	X2006	X2007
P21	X2101	X2102	X2103	X2104	X2105	X2106	X2107

TABLE 13 (Continued)

PILOT	WD (01)	SAT (02)	MAV (03)	ACBT (04)	SAR (05)	NIGHT (06)	COLS (07)
P22	X2201	X2202	X2203	X2204	X2205	X2206	X2207
P23	X2301	X2302	X2303	X2304	X2305	X2306	X2307
P24	X2401	X2402	X2403	X2404	X2405	X2406	X2407
P25	X2501	X2502	X2503	X2504	X2505	X2506	X2507
P26	X2601	X2602	X2603	X2604	X2605	X2606	X2607
P27	X2701	X2702	X2703	X2704	X2705	X2706	X2707
P28	X2801	X2802	X2803	X2804	X2805	X2806	X2807
P29	X2901	X2902	X2903	X2904	X2905	X2906	X2907
P30	X3001	X3002	X3003	X3004	X3005	X3006	X3007
P31	X3101	X3102	X3103	X3104	X3105	X3106	X3107
P32	X3201	X3202	X3203	X3204	X3205	X3206	X3207
P33	X3301	X3302	X3303	X3304	X3305	X3306	X3307
P34	X3401	X3402	X3403	X3404	X3405	X3406	X3407
P35	X3501	X3502	X3503	X3504	X3505	X3506	X3507
P36	X3601	X3602	X3603	X3604	X3605	X3606	X3607
P37	X3701	X3702	X3703	X3704	X3705	X3706	X3707

APPENDIX D

APPENDIX D

FORTRAN COMPUTER ASSISTED SCHEDULING PROGRAM

This appendix contains the program developed to generate the required input for the CDC APEX III LP software package. Although it is written in FORTRAN there is no reason it could not be converted to COBOL or another programming language.

```
      PROGRAM FILLP(INPUT,OUTPUT,TAPE1)
C
C  GENERATE ON TAPE1 INPUT DATA SUITABLE FOR APEX LP PACKAGE
C  FOR PILOT TRAINING FLIGHT ASSIGNMENT PROBLEM
C
C  P1 HOLDS THE INPUT CATEGORY DATA FOR EACH PILOT
C  P2 HOLDS RANKING DATA FOR EACH PILOT ON 5 SORTIE TYPES
C  P3 HOLDS TOTAL AND SORTIE TYPE MAX/MIN FOR EACH PILOT
C  RNKRNK HOLDS PILOT RANKING IN RANK ORDER.  THAT IS IF PILOT
C     NUMBER X IS RANKED FIRST FOR FLIGHT J, THEN RNKRNK(1,J)=X.
C  CUTPER HOLDS CUTPOINT PERCENTAGES FOR SETTING VARIABLE MINS
C     CURRENT VALUES WILL BREAK INTO 10,20,40,20,10 % BRACKETS
C  CUTPT HOLDS CUTPOINTS BASED ON CUTPER AND NUMBER OF PILOTS
C  TABLE CONTAINS 16 VALUES FOR EACH PILOT CATEGORY ENTRY (CURRENTLY 21)
C     VALUES ARE MAX/MIN FOR TOTAL,RU,SAT,NAV,AC-T,SAR,NIGHT,COLS
C     MIN IS NEGATIVE WHERE MIN VALUE MAY VARY PER PILOT'S RANKING
C  FIXED SET TRUE IF MIN VALUES FOR AN ENTRY DO NOT VARY
C  MAXFLT HOLDS MAX ALLOWED TOTAL PER SORTIE TYPE
C  RESPNS IS WORKING AREA FOR INPUT DATA, MOVED TO P1 AND P2
C
       IMPLICIT INTEGER (A-Z)
       DIMENSION P1(50,9),P2(50,5),P3(50,16)
       DIMENSION RNKRNK(50,5)
       REAL CUTPER(4)
       DIMENSION CUTPT(4)
       DIMENSION TABLE(16,21)
       LOGICAL FIXED(21)
       DIMENSION RESPNS(14),RANK(5),MAXFLT(7)
       EQUIVALENCE (RESPNS(1),PNMBR ),(RESPNS(2),TNGCAT),
     X             (RESPNS(3),POSTCT),(RESPNS(4),MONTHS),
     X             (RESPNS(5),CATGRY),(RESPNS(6),STATUS),
     X             (RESPNS(7),IP    ),(RESPNS(8),EXPER ),
     X             (RESPNS(9),GCC   ),(RESPNS(10),RANK(1))
C
C   CURRENTLY SET UP FOR AT MOST 50 PILOTS AND 21 CATEGORIES
C   APPROPRIATE ARRAY SIZES AND FOLLOWING DATA STATEMENT SHOULD
C   BE CHANGED TO CHANGE THESE VALUES.
        DATA MAXPLT,NENTRY /50,21/
C
C   FOLLOWING DATA STATEMENT SETS CUTPOINT PERCENTAGES
        DATA CUTPER /.10,.30,.70,.90/
```

```
C  FOLLOWING SET UP THE MAX/MIN VALUES FOR VARIOUS PILOT CATEGORIES
      DATA ((TABLE(J,K),J=1,16),K=1,10) /
     1 55. 46.  9. -4.  9. -5.  7. -3.  3. -2.  5. -1. 10.  5. 20. 15.
     2 72. 56. 10. -5. 12. -7.  7. -3.  3. -2.  9. -5. 10.  5. 21. 16.
     3 81. 75. 11. -6. 12. -5.  9. -5.  7. -2.  9. -5. 10.  5. 22. 17.
     4 42. 33.  5. -4.  9. -5.  7. -3.  3. -2.  5. -1.  6.  2.  9.  6.
     5 56. 50. 10. -6. 12. -7.  7. -3.  5. -2.  9. -5.  7.  5. 10.  6.
     6 65. 59. 11. -5. 12. -5.  9. -5.  7. -2.  9. -5. 10.  5. 11.  9.
     7 39. 30.  3.  2. 10.  2.  5.  2.  3.  2.  5.  2.  6.  2.  9.  6.
     8 50. 40.  9. -5.  9. -5.  7. -3.  5. -0.  6. -2.  5.  2. 10.  9.
     9 61. 50. 12. -8. 12. -8.  8. -4.  5. -2.  8. -4.  5.  2. 11. 10.
     A 75. 59. 12. -7. 13. -8. 10. -5. 10. -4. 11. -7. 11.  5. 12. 10 /
      DATA ((TABLE(J,K),J=1,16),K=11,20) /
     1 59. 49.  9. -5.  9. -5.  7. -3.  3. -0.  6. -2.  5.  2. 25. 19.
     2 70. 59. 12. -8. 12. -8.  8. -4.  5. -2.  9. -4.  6.  2. 25. 19.
     3 89. 77. 12. -7. 13. -8. 13. -5.  9. -4. 11. -7. 11.  5. 25. 19.
     4 50. 36. 10. -6. 12. -8.  5. -2.  5. -0.  5. -2.  6.  2. 10.  4.
     5 71. 59. 10. -5. 13. -5. 10. -5.  9. -4.  5. -4.  5.  5. 12.  6.
     6 97. 84. 16.-12. 18.-13. 12. -5. 12. -6. 10. -6. 15.  5. 13.  8.
     7 39. 30.  6.  2. 10.  2.  6.  2.  5.  2.  5.  2.  4.  2.  9.  6.
     8 69. 50. 17. 11. 13. 10.  6.  6.  4.  5.  6.  3.  4.  2. 14.  8.
     9 66. 50. 16. 10. 12.  9.  7.  5.  7.  4.  6.  3.  3.  2. 13.  9.
     A 72. 60. 15.  9. 10.  7.  6.  4.  5.  3.  6.  3.  3.  2. 16. 10 /
      DATA (TABLE(J,21),J=1,16) /
     1 57. 45. 13. 10.  7.  4.  5.  3.  5.  5.  5.  3.  4.  2. 18. 12 /
C
C  KEYS TO TABLE ENTRIES IN FOLLOWING LAYOUT
C
C**************************************************************************
C TABLE  TNG       NEXT     MONTHS   PILOT   PILOT                   GCC
C ENTRY  CTGRY     STATUS   TO COMP  CTGRY   STATUS   IP    EXPER  LEVEL
C**************************************************************************
C     1   CT                         STAFF    MR      YES           A
C     2   CT                         STAFF    MR      YES           B
C     3   CT                         STAFF    MR      YES           C
C     4   CT                         STAFF    MR      NO            A
C     5   CT                         STAFF    MR      NO            B
C     6   CT                         STAFF    MR      NO            C
C     7   CT                         STAFF    MS
C     8   CT                         PRIM             YES   EXP     A
C     9   CT                         PRIM             YES   EXP     B
C    10   CT                         PRIM             YES   EXP     C
C    11   CT                         PRIM             NO    EXP     A
C    12   CT                         PRIM             NO    EXP     B
C    13   CT                         PRIM             NO    EXP     C
C    14   CT                         PRIM                   INEXP   A
C    15   CT                         PRIM                   INEXP   B
C    16   CT                         PRIM                   INEXP   C
C    17    IQT/MQT   MS
C    18    IQT/MQT   MR        1
C    19    IQT/MQT   MR        2
C    20    IQT/MQT   MR        3
C    21    IQT/MQT   MR        4
C**************************************************************************
C
```

```
C
      CALL CONNEC(5LINPUT)
      CALL CONNEC(6LOUTPUT)
C
C  DETERMINE WHICH ENTRIES WILL HAVE FIXED MINIMUMUMS
C
      DO 50 J=1,NENTRY
      DO 10 K=4,12,2
      IF(TABLE(K,J).LE.0) GO TO 20
10    CONTINUE
      FIXED(J)=.TRUE.
      GO TO 50
20    FIXED(J)=.FALSE.
50    CONTINUE
C
C  READ TOTAL NUMBER PILOTS. MAKE SURE ITS UNDER MAX SPACE.
C
      PRINT 1001
      READ *,TOTPLT
      IF(TOTPLT.LE.MAXPLT) GO TO 70
      PRINT 2001,MAXPLT
      STOP
C
C  SET UP CUTPOINTS TO BE USED FOR VARIABLE MINS
C
70    DO 80 J=1,4
80    CUTPT(J)=CUTPER(J)*FLOAT(TOTPLT)+0.5
C
C  READ OVERALL MAX FLIGHTS BY TYPE
C
      PRINT 1002
      READ *,MAXFLT
C
C  START INPUT FOR EACH PILOT.  FIRST CLEAR OUT RESPONSE SPACE.
C
100   DO 101 J=1,14
101   RESPNS(J)=0
C
C  PILOT NUMBER, NOT OVER TOTAL AND NOT ALREADY USED.
C    PILOT NUMBER 999 FLAGS END OF INPUT
C
103   PRINT 1003
      READ *,PNMBR
      IF(PNMBR.EQ.999) GO TO 300
      IF(PNMBR.LE.TOTPLT) GO TO 10301
      PRINT 2002,TOTPLT
      GO TO 103
10301 IF(PI(PNMBR,1).EQ.0) GO TO 104
      PRINT 2003
      GO TO 103
C
C  TRAINING CATEGORY--1=CT,2=IQT/MQT
```

```
104    PRINT 1004
       READ *,TNGCAT
       IF(TNGCAT.EQ.1 .OR.TNGCAT.EQ.2) GO TO 10401
       PRINT 2000
       GO TO 104
C JUMP FOR CT, STAY HERE FOR IQT/MQT
10401 IF(TNGCAT.EQ.1) GO TO 107
C
C  HAVE IQT/MQT, GET CATEGORY AFTER TNG--1=MR,2=MS
C
105    PRINT 1005
       READ *,POSTCT
       IF(POSTCT.EQ.1 .OR. POSTCT.EQ.2) GO TO 10501
       PRINT 2000
       GO TO 105
C
C  GET MONTHS FOR MR.
C
10501 IF(POSTCT.EQ.2) GO TO 112
106    PRINT 1006
       READ *,MONTHS
       IF(MONTHS.GT.0 .AND. MONTHS.LE.4) GO TO 112
       PRINT 2000
       GO TO 106
C
C  HAVE TNG CATEGORY CT, GET PILOT CATEGORY--1=PRIMARY,2=STAFF
C
107    PRINT 1007
       READ *,CATGRY
       IF(CATGRY.EQ.1 .OR. CATGRY.EQ.2) GO TO 10701
       PRINT 2000
       GO TO 107
C
C  FOR PRIMARY STAY AND GET EXPERIENCE--1=EXP,2=INEXP
C
10701 IF(CATGRY.EQ.2) GO TO 109
108    PRINT 1008
       READ *,EXPER
       IF(EXPER.EQ.1 .OR.EXPER.EQ.2) GO TO 10801
       PRINT 2000
       GO TO 108
C PICK UP IP STATE FOR EXPERIENCED.
10801 IF(EXPER.EQ.1) GO TO 110
       GO TO 111
C
C  HAVE A STAFF PILOT, DETERMINE STATUS--MR=1,MS=2
C
109    PRINT 1009
       READ *,STATUS
       IF(STATUS.EQ.1 .OR.STATUS.EQ.2) GO TO 10901
       PRINT 2000
       GO TO 109
C  SKIP TO RANKS IF MS.
10901 IF(STATUS.EQ.2) GO TO 112
```

```
C  IS PILOT IP?--1=YES,2=NO
C
110    PRINT 1010
       READ *,IP
       IF(IP.EQ.1 .OR.IP.EQ.2) GO TO 111
       PRINT 2000
       GO TO 110
C
C GCC LEVEL--1=A,2=B,3=C
C
111    PRINT 1011
       READ *,GCC
       IF(GCC.GT.0 .AND.GCC.LE.3) GO TO 112
       PRINT 2000
       GO TO 111
C
C  NOW GET THIS PILOTS RANKINGS BY FLIGHT TYPE
C
112    PRINT 1012
       READ *,RANK
C  CHRANK INSURES LEGAL RANKS, SAVES THEM IN RNKRNK.
C    WILL TAKE ALTERNATE RETURN IF PROBLEMS DETECTED.
       CALL CHRANK(PNMBR,TOTPLT,RANK,RNKRNK,P2),RETURNS(112)
C
C  DETERMINE WHICH TABLE ENTRY TO USE
C    NOTE THAT THIS LOGIC DEPENDS ON UNUSED SELECTION ITEMS
C    BEING ZERO TO WORK PROPERLY.
C
       ENTRY=0
       IF(TNGCAT.NE.1) GO TO 150
       IF(CATGRY.EQ.1) ENTRY=7
       IF(STATUS.EQ.2) ENTRY=7
       IF(IP.EQ.2) ENTRY=ENTRY+3
       IF(EXPER.EQ.2) ENTRY=ENTRY+6
       ENTRY=ENTRY+GCC
       GO TO 200
150    ENTRY=17+MONTHS
C
C  SAVE THIS PILOT'S DATA AND GET THE NEXT ENTRY
C
200    P1(PNMBR,1)=ENTRY
       DO 210 J=2,9
210    P1(PNMBR,J)=RESPNS(J)
       DO 220 J=1,5
220    P2(PNMBR,J)=RANK(J)
       GO TO 100
C
C  ALL DATA HAS BEEN INPUT.  NOW SET UP REQUIRED VALUES
C
300    DO 400 PILOT=1,TOTPLT
       ENTRY=P1(PILOT,1)
       DO 310 J=1,15
310    P3(PILOT,J)=TABLE(J,ENTRY)
C
```

```
C  IF MINS CANT VARY THAT IS ALL THAT IS NEEDED.
C
      IF(FIXED(ENTRY)) GO TO 400
C
C  MINS CAN VARY...FIRST GET THIS PILOT'S RANKING
C
      DO 320 J=1,5
320   RANK(J)=P2(PILOT,J)
C
C  NOW FOR FIRST FIVE SORTIE TYPES PICK UP THE BASE MIN
C    (WHICH IS A NEGATIVE) AND DECIDE HOW MUCH TO BUMP IT
C    BASED ON WHERE THE RANKING HITS THE CUTPOINTS.
C
      DO 350 K=1,5
      POINT=2*(K-1)
      BASE=IABS(P3(PILOT,POINT))
      DO 330 J=1,4
      IF(RANK(K).LE.CUTPT(J)) GO TO 335
330   CONTINUE
      J=5
335   BUMP=J-1
      P3(PILOT,POINT)=BASE+BUMP
350   CONTINUE
400   CONTINUE
C
C  RERANK WILL TOSS OUT INFEASIBLE RANKINGS AND CLEAN UP THE
C      RANKING ARRAYS AS NEEDED.
C
      CALL RERANK(TOTPLT,P2,RNKRNK,P3)
C
C  CARDS GENERATES THE APEX INPUT ON TAPE1
C
      CALL CARDS(TOTPLT,MAXFLT,P3,P2,RNKRNK)
C
      STOP
C
1001  FORMAT(" TOTAL NUMBER OF PILOTS ?")
1002  FORMAT(" MAX NUMBER OF WD,SAT,WAV,ACT,SAW,NIGHT,COLS SORTIES",
     1 /," ?")
1003  FORMAT(" PILOT NUMBER--(999 TO STOP) ?")
1004  FORMAT(" TRAINING CATEGORY--CT=1,IUT/MQT=2 ?")
1005  FORMAT(" CATEGORY AFTER IUT/MQT--MR=1,MS=2 ?")
1006  FORMAT(" MONTHS TO COMPLETE IUT/MQT--1,2,3 OR 4 ?")
1007  FORMAT(" PILOT CATEGORY--PRIMARY=1,STAFF=2 ?")
1009  FORMAT(" PILOT STATUS--MR=1,MS=2 ?")
1010  FORMAT(" IS PILOT AN IP--YES=1,NO=2 ?")
1008  FORMAT(" EXPERIENCED=1,INEXPERIENCED=2 ?")
1011  FORMAT(" BCC LEVEL--A=1,B=2,C=3 ?")
1012  FORMAT(" RANKING FOR WD,SAT,WAV,ACT,SAW SORTIES",/," ?")
C
2000  FORMAT(" ILLEGAL ENTRY---TRY AGAIN")
2001  FORMAT(" MAX PILOTS ALLOWED IS",I4," MUST CHANGE PROGRAM")
2002  FORMAT(" PILOT NUMBER CAN NOT BE GREATER THAN TOTAL OF",I4)
2003  FORMAT(" DATA FOR THIS PILOT NUMBER ALREADY ENTERED")
      END
```

```
      SUBROUTINE RERANK(TOT,RANK,RANK2,MAX)
C
C  WHERE PILOT PA IS RANKED "N" AND PILOT PB IS RANKED "N+1", WE
C  DESIRE THE CONSTRAINT THAT PA FLIGHTS BE LESS OR EQUAL PB FLIGHTS.
C  THIS IS INFEASIBLE IF PB'S MAX IS LESS THAN PA'S MIN.
C  RERANK CHECKS FOR INFEASIBILITIES OF THIS NATURE AND, WHEN FOUND,
C  REMOVES PB FROM THE RANKING SCHEME.
C
      IMPLICIT INTEGER (A-Z)
      DIMENSION RANK(50,5),RANK2(50,5)
      DIMENSION MAX(50,10)
C
C     DO 10 J=1,5
C     DO 10 K=1,TOT
C     PLACE=RANK(K,J)
C10   RANK2(PLACE,J)=K
C
C  LOOP 30 FIVE TIMES FOR THE FIVE SORTIE TYPES TO BE CHECKED.
C  MAXP AND MINP POINT TO MAX AND MIN ENTRIES FOR THE SORTIE TYPE.
C  START WITH THE PILOT RANKED FIRST AS PA AND PILOT RANKED SECOND
C  AS PB AND MAKE THE CHECK. IF FEASIBLE, THE SECOND PILOT BECOMES
C  PA AND THIRD PILOT BECOMES PB AND SO ON TILL ALL ARE CHECKED.
C  IF INFEASIBLE, PB IS DROPPED OUT (GIVEN A ZERO RANK), THE NEXT
C  RANKED PILOT IS PICKED UP AS PB AND THE CHECK MADE AGAIN.
C
      DO 30 J=1,5
      MAXP=2*J-1
      MINP=MAXP+1
      RA=1
      RB=1
20    RB=RB+1
      IF(RB.GT.TOT) GO TO 30
      PA=RANK2(RA,J)
      PB=RANK2(RB,J)
C  .LT. CHECK WOULD SUFFICE TO FIND INFEASIBILITIES
C  AM USING .LE. TO CUT DOWN ON NUMBER OF CONSTRAINTS
      IF(MAX(PB,MAXP).LE.MAX(PA,MINP)) GO TO 25
      RA=RB
      GO TO 20
25    RANK2(RB,J)=0
      RANK(PB,J)=0
      GO TO 20
30    CONTINUE
C
C  NOW MUST CLEAN UP RANK ARRAY.  SUPPOSE PILOT RANKED 3 HAS BEEN
C  DROPPED ABOVE. THAT MEANS PILOTS RANKED 4,5,6, ETC. NOW SHOULD
C  BE RANKED 3,4,5, ETC.  LOOP 50 ACCOMPLISHES THIS.
C
      DO 50 J=1,5
      RNK=1
      RA=1
40    PA=RANK2(RA,J)
      IF(PA.LE.0) GO TO 45
      RANK(PA,J)=RNK
```

```
      RNK=RNK+1
45    RA=RA+1
      IF(RA.LE.TOT) GO TO 40
50    CONTINUE
C
C  ALSO MUST CLEAN UP THE PILOT BY RANKS ARRAY.  IF PILOTS WERE
C  DROPPED ABOVE THIS ARRAY NOW HAS ZERO ENTRIES.  MOVE ALL NON-ZERO
C  ENTRIES TO FRONT OF THE ARRAY AND ZERO FILL AT END.
C
      DO 80 J=1,5
      IN=1
      OUT=1
70    IF(RANK2(IN,J).EQ.0) GO TO 75
      RANK2(OUT,J)=RANK2(IN,J)
      OUT=OUT+1
75    IN=IN+1
      IF(IN.LE.TOT) GO TO 70
      IF(OUT.GT.TOT) GO TO 80
      DO 78 K=OUT,TOT
78    RANK2(K,J)=0
80    CONTINUE
C
      RETURN
      END
      SUBROUTINE CARDS(NPLT,MAXFLT,MAX,RANK,RANK2)
C
C  GENERATE APEX INPUT DATA
C
      IMPLICIT INTEGER(A-Z)
      DIMENSION RANK(50,5),RANK2(50,5)
      DIMENSION NAMES(7), MAXFLT(7)
      DIMENSION MAX(50,15)
C
      DATA NTP /7/
      DATA NAMES /2HRO,3HSAT,3HMAV,4HACST,3HSAR,5HNIGHT,4HCOLS /
C
C  NAME HEADER AND ROWS SECTION
C
      WRITE(1,2001)
2001  FORMAT("NAME",T15,"PANNELL",/,"ROWS")
C  ONE ROW FOR EACH FLIGHT TYPE TOTAL
      DO 100 K=1,NTP
100   WRITE(1,2002) NAMES(K)
2002  FORMAT(5H  L T,A5)
C  OVERALL TOTAL IS LINEAR COMBINATION OF THE FLIGHT TYPE TOTALS
      DO 110 K=1,NTP,2
      IF(K.EQ.NTP) GO TO 111
      WRITE(1,2003) NAMES(K),NAMES(K+1)
      GO TO 110
111   WRITE(1,2004) NAMES(K)
110   CONTINUE
2003  FORMAT(" ON TOTALS",T15,"T",A5,T25,"1.",T40,"T",A5,T50,"1.")
2004  FORMAT(" ON TOTALS",T15,"T",A5,T25,"1.")
C  ONE ROW FOR EACH PILOT TOTAL
```

```
      DO 120 J=1,NPLT
120   WRITE(1,2005) J
2005  FORMAT("  L P",I2.2)
C
C  CONSTRAINT ROWS BASED ON PILOT RANKING FOR EACH FLIGHT TYPE
C
      DO 150 K=1,5
      DO 130 J=1,NPLT
      P1=RANK2(J,K)
      P2=RANK2(J+1,K)
      IF(P2.LE.0) GO TO 150
130   WRITE(1,2101) P1,P2,NAMES(K)
150   CONTINUE
2101  FORMAT(5H  L C,2I2.2,A5)
C
C  COLUMNS SECTION
C
      WRITE(1,2006)
2006  FORMAT("COLUMNS")
C  ONE COLUMN FOR EACH PILOT/FLIGHT TYPE COMBINATION
      DO 250 J=1,NPLT
      DO 240 K=1,NTP
C  ENTERS INTO FLIGHT TYPE AND PILOT TYPE TOTALS
      WRITE(1,2007) J,NAMES(K),NAMES(K),J
2007  FORMAT(T5,"P",I2.2,A5,T15,"T",A5,T25,"1.",
     *  T40,"P",I2.2,T50,"1.")
C  ENTER INTO RANKING CONSTRAINT, FIRST FIVE FLIGHT TYPES
      IF(K.GT.5) GO TO 240
      CURPOS=RANK(J,K)
      IF(CURPOS.EQ.0) GO TO 240
      PREV=RANK2(CURPOS-1,K)
      NEXT=RANK2(CURPOS+1,K)
      IF(CURPOS.EQ.1) PREV=0
      IF(CURPOS.GE.NPLT) NEXT=0
      IF(PREV.EQ.0) GO TO 210
      WRITE(1,2107) J,NAMES(K),PREV,J,NAMES(K)
2107  FORMAT(T5,"P",I2.2,A5,T15,"C",2I2.2,A5,T25,"-1.")
210   IF(NEXT.EQ.0) GO TO 240
      WRITE(1,2108) J,NAMES(K),J,NEXT,NAMES(K)
2108  FORMAT(T5,"P",I2.2,A5,T15,"C",2I2.2,A5,T25,"1.")
240   CONTINUE
250   CONTINUE
C
C  RIGHT HAND SIDE SECTION
C
      WRITE(1,2008)
2008  FORMAT("RHS")
C  MAX FOR EACH FLIGHT TYPE TOTAL
      DO 300 K=1,NTP
300   WRITE(1,2009) NAMES(K),MAXFLT(K)
2009  FORMAT(T5,"RHS",T15,"T",A5,T25,I3)
C  MAX FOR EACH PILOT TOTAL
      DO 310 J=1,NPLT
310   WRITE(1,2010) J,MAX(J,1)
2010  FORMAT(T5,"RHS",T15,"P",I2.2,T25,I3)
```

```
C   RANGES SECTION
C   USING RANGES TO SET MIN CONSTRAINT ON PILOT TOTALS, MAX
C   WAS SET AT RIGHT HAND SIDE.
C
      WRITE(1,2011)
2011  FORMAT("RANGES")
      DO 400 J=1,NPLT
      R=MAX(J,1)-MAX(J,2)
      WRITE(1,2012) J,R
400   CONTINUE
2012  FORMAT(T5,"RANGES",T15,"P",I2.2,T25,I3)
C
C   BOUNDS SECTION
C   SET UPPER AND LOWER INTEGER BOUNDS FOR EACH PILOT/FLIGHT
C   TYPE COMBINATION
C
      WRITE(1,2013)
2013  FORMAT("BOUNDS")
      DO 500 J=1,NPLT
      DO 500 K=1,NTP
      WRITE(1,2014) IUP,J,NAMES(K),MAX(J,2*K+1)
      WRITE(1,2014) ILO,J,NAMES(K),MAX(J,2*K+2)
500   CONTINUE
2014  FORMAT(A4,"BOUNDS",T15,"P",I2.2,A5,T25,I3)
C
      DATA IUP,ILO /4H UI ,4H LI /
C
      WRITE(1,2015)
2015  FORMAT("ENDATA")
C
      RETURN
      END
      SUBROUTINE CHRANK(PILOT,TOTAL,RANK,RANK2,P2),RETURNS(AGAIN)
      IMPLICIT INTEGER(A-Z)
C
C   CHECK FOR RANK PROBLEMS
C
      DIMENSION RANK(5),RANK2(50,5),P2(50,5)
C
C   RANKS IN LEGAL RANGE?
C
      DO 10 J=1,5
      IF(RANK(J).LE.0 .OR. RANK(J).GT.TOTAL) GO TO 100
10    CONTINUE
C
C   RANK ALREADY ASSIGNED TO ANOTHER PILOT?
C
      DO 20 J=1,5
      K=RANK(J)
      IF(RANK2(K,J).NE.0) GO TO 200
20    CONTINUE
```

AD-A092 924 ARMY COMMAND AND GENERAL STAFF COLL FORT LEAVENWORTH KS F/G 5/9

A LINEAR PROGRAMMING APPLICATION TO AIRCREW SCHEDULING.(U)

JUN 80 C L PANNELL

UNCLASSIFIED SBIE-AD-E750 038 NL

2 of 2

AD A092924

END

DATE FILMED

1 81

DTIC

```
C  SAVE IN RANKING ARRAY
C
      DO 30 J=1,5
      K=RANK(J)
30    RANK2(K,J)=PILOT
      RETURN
C
100   PRINT 101,TOTAL
101   FORMAT(" RANKS MUST BE IN RANGE 1 TO = PILOTS =",I3)
      RETURN AGAIN
C
200   PRIOR=RANK2(K,J)
      PRINT 201,PRIOR,(P2(PRIOR,L),L=1,5)
201   FORMAT(" CONFLICT WITH PILOT",I3," RANKS=",5I3)
      RETURN AGAIN
      END
```

APPENDIX E

APPENDIX E

FORMATTED INPUT

The computer listing in this appendix is the output of the FORTRAN computer assisted scheduling program generated by the CARDS subroutine. It serves as the input to the CDC APEX III LP software package.

```
NAME          PANNELL
ROWS
 L  TWD
 L  TSAT
 L  TMAV
 L  TACRT
 L  TSAW
 L  TNIGHT
 L  TCOLS
 DN TOTALS    TWD        1.          TSAT      1.
 DN TOTALS    TMAV       1.          TACST     1.
 DN TOTALS    TSAP       1.          TNIGHT    1.
 DN TOTALS    TCOLS      1.
 L  P01
 L  P02
 L  P03
 L  P04
 L  P05
 L  P06
 L  P07
 L  P08
 L  P09
 L  P10
 L  P11
 L  P12
 L  P13
 L  P14
 L  P15
 L  P16
 L  P17
 L  P18
 L  P19
 L  P20
 L  P21
 L  P22
 L  P23
 L  P24
 L  P25
 L  P26
 L  P27
 L  P28
 L  P29
 L  P30
 L  P31
 L  P32
 L  P33
 L  P34
 L  P35
 L  P36
 L  P37
 L  C1416WD
 L  C1609WD
 L  C0932WD
 L  C3211WD
 L  C1114WD
 L  C1902WD
 L  C0235WD
 L  C3517WD
 L  C1720WD
 L  C2024WD
 L  C2415WD
 L  C1525WD
 L  C2529WD
 L  C2925WD
 L  C2604WD
```

```
L C0410=0
L C1012=0
L C1225=0
L C2837=0
L C2309SAT
L C0914SAT
L C1911SAT
L C1102SAT
L C0224SAT
L C2924SAT
L C2804SAT
L C0420SAT
L C2025SAT
L C2510SAT
L C1012SAT
L C1225SAT
L C2637SAT
L C3715SAT
L C1532SAT
L C3224SAT
L C2419SAT
L C3613MAV
L C1304MAV
L C0914MAV
L C1415MAV
L C1324MAV
L C2932MAV
L C3223MAV
L C2324MAV
L C2420MAV
L C2004MAV
L C0415MAV
L C1537MAV
L C3728MAV
L C2812MAV
L C1226MAV
L C2619MAV
L C1925MAV
L C2511MAV
L C1110MAV
L C1015ACBT
L C1813ACBT
L C1305ACBT
L C0537ACBT
L C3719ACBT
L C1925ACBT
L C2605ACBT
L C0504ACBT
L C0923ACBT
L C2312ACBT
L C1232ACBT
L C3224ACBT
L C2904ACBT
L C0415ACBT
L C1502ACBT
L C0236ACBT
L C3625ACBT
L C2524ACBT
L C2420ACBT
L C2011ACBT
L C1128ACBT
L C2309SAW
L C0905SAW
L C0514SAW
L C1407SAW
L C0718SAW
```

```
    L  C1816SAR
    L  C1633SAR
    L  C3303SAR
    L  C0329SAR
    L  C2931SAR
    L  C3113SAR
    L  C1306SAR
    L  C0636SAR
    L  C3629SAR
    L  C2932SAR
    L  C3237SAR
    L  C3711SAR
    L  C1102SAR
    L  C0204SAR
    L  C0420SAR
    L  C2015SAR
    L  C1514SAR
    L  C1928SAR
    L  C2925SAR
    L  C2524SAR
    L  C2412SAR
    L  C1210SAR
COLUMNS
       P01WD       TWD          1.               P01          1.
       P01SAT      TSAT         1.               P01          1.
       P01MAV      TMAV         1.               P01          1.
       P01ACBT     TACBT        1.               P01          1.
       P01SAR      TSAR         1.               P01          1.
       P01NIGHT    TNIGHT       1.               P01          1.
       P01COLS     TCOLS        1.               P01          1.
       P02WD       TWD          1.               P02          1.
       P02WD       C1402WD     -1.
       P02WD       C0235WD      1.
       P02SAT      TSAT         1.               P02          1.
       P02SAT      C1102SAT    -1.
       P02SAT      C0229SAT     1.
       P02MAV      TMAV         1.               P02          1.
       P02ACBT     TACBT        1.               P02          1.
       P02ACBT     C1502ACBT   -1.
       P02ACBT     C0236ACBT    1.
       P02SAR      TSAR         1.               P02          1.
       P02SAR      C1102SAR    -1.
       P02SAR      C0204SAR     1.
       P02NIGHT    TNIGHT       1.               P02          1.
       P02COLS     TCOLS        1.               P02          1.
       P03WD       TWD          1.               P03          1.
       P03SAT      TSAT         1.               P03          1.
       P03MAV      TMAV         1.               P03          1.
       P03ACBT     TACBT        1.               P03          1.
       P03SAR      TSAR         1.               P03          1.
       P03SAR      C3303SAR    -1.
       P03SAR      C0329SAR     1.
       P03NIGHT    TNIGHT       1.               P03          1.
       P03COLS     TCOLS        1.               P03          1.
       P04WD       TWD          1.               P04          1.
       P04WD       C2504WD     -1.
       P04WD       C0410WD      1.
       P04SAT      TSAT         1.               P04          1.
       P04SAT      C2504SAT    -1.
       P04SAT      C0420SAT     1.
       P04MAV      TMAV         1.               P04          1.
       P04MAV      C2004MAV    -1.
       P04MAV      C0415MAV     1.
       P04ACBT     TACBT        1.               P04          1.
       P04ACBT     C2904ACBT   -1.
       P04ACBT     C0415ACBT    1.
```

P04SAR	TSAR	1.	P04	1.
P04SAR	C0204SAR	-1.		
P04SAR	C0420SAR	1.		
P04NIGHT	TNIGHT	1.	P04	1.
P04CULS	TCULS	1.	P04	1.
P05WD	TWD	1.	P05	1.
P05SAT	TSAT	1.	P05	1.
P05MAV	TMAV	1.	P05	1.
P05ACBT	TACBT	1.	P05	1.
P05ACBT	C1305ACBT	-1.		
P05ACBT	C0537ACBT	1.		
P05SAR	TSAR	1.	P05	1.
P05SAR	C0405SAR	-1.		
P05SAR	C0514SAR	1.		
P05NIGHT	TNIGHT	1.	P05	1.
P05CULS	TCULS	1.	P05	1.
P06WD	TWD	1.	P06	1.
P06SAT	TSAT	1.	P06	1.
P06MAV	TMAV	1.	P06	1.
P06ACBT	TACBT	1.	P06	1.
P06ACBT	C2506ACBT	-1.		
P06ACBT	C0604ACBT	1.		
P06SAR	TSAR	1.	P06	1.
P06SAR	C1306SAR	-1.		
P06SAR	C0636SAR	1.		
P06NIGHT	TNIGHT	1.	P06	1.
P06CULS	TCULS	1.	P06	1.
P07WD	TWD	1.	P07	1.
P07SAT	TSAT	1.	P07	1.
P07MAV	TMAV	1.	P07	1.
P07ACBT	TACBT	1.	P07	1.
P07SAR	TSAR	1.	P07	1.
P07SAR	C1407SAR	-1.		
P07SAR	C0718SAR	1.		
P07NIGHT	TNIGHT	1.	P07	1.
P07CULS	TCULS	1.	P07	1.
P08WD	TWD	1.	P08	1.
P08SAT	TSAT	1.	P08	1.
P08MAV	TMAV	1.	P08	1.
P08ACBT	TACBT	1.	P08	1.
P08SAR	TSAR	1.	P08	1.
P08NIGHT	TNIGHT	1.	P08	1.
P08CULS	TCULS	1.	P08	1.
P09WD	TWD	1.	P09	1.
P09WD	C1509WD	-1.		
P09WD	C0932WD	1.		
P09SAT	TSAT	1.	P09	1.
P09SAT	C2309SAT	-1.		
P09SAT	C0913SAT	1.		
P09MAV	TMAV	1.	P09	1.
P09MAV	C1309MAV	-1.		
P09MAV	C0914MAV	1.		
P09ACBT	TACBT	1.	P09	1.
P09ACBT	C0509ACBT	-1.		
P09ACBT	C0923ACBT	1.		
P09SAR	TSAR	1.	P09	1.
P09SAR	C2309SAR	-1.		
P09SAR	C0905SAR	1.		
P09NIGHT	TNIGHT	1.	P09	1.
P09CULS	TCULS	1.	P09	1.
P10WD	TWD	1.	P10	1.
P10WD	C0410WD	-1.		
P10WD	C1012WD	1.		
P10SAT	TSAT	1.	P10	1.
P10SAT	C2510SAT	-1.		
P10SAT	C1012SAT	1.		

P10MAV	TMAV	1.	P10	1.
P10MAV	C1110MAV	-1.		
P10ACBT	TACBT	1.	P10	1.
P10ACBT	C1013ACBT	1.		
P10SAR	TSAR	1.	P10	1.
P10SAR	C1210SAR	-1.		
P10NIGHT	TNIGHT	1.	P10	1.
P10COLS	TCOLS	1.	P10	1.
P11WD	TWD	1.	P11	1.
P11WD	C3211WD	-1.		
P11WD	C1119WD	1.		
P11SAT	TSAT	1.	P11	1.
P11SAT	C1311SAT	-1.		
P11SAT	C1102SAT	1.		
P11MAV	TMAV	1.	P11	1.
P11MAV	C2511MAV	-1.		
P11MAV	C1110MAV	1.		
P11ACBT	TACBT	1.	P11	1.
P11ACBT	C2011ACBT	-1.		
P11ACBT	C1126ACBT	1.		
P11SAR	TSAR	1.	P11	1.
P11SAR	C3711SAR	-1.		
P11SAR	C1102SAR	1.		
P11NIGHT	TNIGHT	1.	P11	1.
P11COLS	TCOLS	1.	P11	1.
P12WD	TWD	1.	P12	1.
P12WD	C1012WD	-1.		
P12WD	C1228WD	1.		
P12SAT	TSAT	1.	P12	1.
P12SAT	C1012SAT	-1.		
P12SAT	C1226SAT	1.		
P12MAV	TMAV	1.	P12	1.
P12MAV	C2412MAV	-1.		
P12MAV	C1225MAV	1.		
P12ACBT	TACBT	1.	P12	1.
P12ACBT	C2312ACBT	-1.		
P12ACBT	C1232ACBT	1.		
P12SAR	TSAR	1.	P12	1.
P12SAR	C2412SAR	-1.		
P12SAR	C1210SAR	1.		
P12NIGHT	TNIGHT	1.	P12	1.
P12COLS	TCOLS	1.	P12	1.
P13WD	TWD	1.	P13	1.
P13SAT	TSAT	1.	P13	1.
P13MAV	TMAV	1.	P13	1.
P13MAV	C3613MAV	-1.		
P13MAV	C1309MAV	1.		
P13ACBT	TACBT	1.	P13	1.
P13ACBT	C1513ACBT	-1.		
P13ACBT	C1305ACBT	1.		
P13SAR	TSAR	1.	P13	1.
P13SAR	C3113SAR	-1.		
P13SAR	C1306SAR	1.		
P13NIGHT	TNIGHT	1.	P13	1.
P13COLS	TCOLS	1.	P13	1.
P14WD	TWD	1.	P14	1.
P14WD	C1416WD	1.		
P14SAT	TSAT	1.	P14	1.
P14MAV	TMAV	1.	P14	1.
P14MAV	C0914MAV	-1.		
P14MAV	C1413MAV	1.		
P14ACBT	TACBT	1.	P14	1.
P14SAR	TSAR	1.	P14	1.
P14SAR	C0514SAR	-1.		
P14SAR	C1407SAR	1.		
P14NIGHT	TNIGHT	1.	P14	1.

P14COLS	TCOLS	1.	P14	1.
P15WD	TWD	1.	P15	1.
P15WD	C2415WD	-1.		
P15WD	C1525WD	1.		
P15SAT	TSAT	1.	P15	1.
P15SAT	C3715SAT	-1.		
P15SAT	C1532SAT	1.		
P15MAV	TMAV	1.	P15	1.
P15MAV	C0415MAV	-1.		
P15MAV	C1537MAV	1.		
P15ACBT	TACBT	1.	P15	1.
P15ACBT	C0415ACBT	-1.		
P15ACBT	C1502ACBT	1.		
P15SAR	TSAR	1.	P15	1.
P15SAR	C2015SAR	-1.		
P15SAR	C1519SAR	1.		
P15NIGHT	TNIGHT	1.	P15	1.
P15COLS	TCOLS	1.	P15	1.
P16WD	TWD	1.	P16	1.
P16WD	C1416WD	-1.		
P16WD	C1609WD	1.		
P16SAT	TSAT	1.	P16	1.
P16MAV	TMAV	1.	P16	1.
P16ACBT	TACBT	1.	P16	1.
P16SAR	TSAR	1.	P16	1.
P16SAR	C1616SAR	-1.		
P16SAR	C1633SAR	1.		
P16NIGHT	TNIGHT	1.	P16	1.
P16COLS	TCOLS	1.	P16	1.
P17WD	TWD	1.	P17	1.
P17WD	C3517WD	-1.		
P17WD	C1720WD	1.		
P17SAT	TSAT	1.	P17	1.
P17MAV	TMAV	1.	P17	1.
P17ACBT	TACBT	1.	P17	1.
P17SAR	TSAR	1.	P17	1.
P17NIGHT	TNIGHT	1.	P17	1.
P17COLS	TCOLS	1.	P17	1.
P18WD	TWD	1.	P18	1.
P18SAT	TSAT	1.	P18	1.
P18SAT	C0918SAT	-1.		
P18SAT	C1811SAT	1.		
P18MAV	TMAV	1.	P18	1.
P18MAV	C1418MAV	-1.		
P18MAV	C1829MAV	1.		
P18ACBT	TACBT	1.	P18	1.
P18ACBT	C1018ACBT	-1.		
P18ACBT	C1813ACBT	1.		
P18SAR	TSAR	1.	P18	1.
P18SAR	C0718SAR	-1.		
P18SAR	C1818SAR	1.		
P18NIGHT	TNIGHT	1.	P18	1.
P18COLS	TCOLS	1.	P18	1.
P19WD	TWD	1.	P19	1.
P19WD	C1119WD	-1.		
P19WD	C1902WD	1.		
P19SAT	TSAT	1.	P19	1.
P19SAT	C2419SAT	-1.		
P19MAV	TMAV	1.	P19	1.
P19MAV	C2519MAV	-1.		
P19MAV	C1925MAV	1.		
P19ACBT	TACBT	1.	P19	1.
P19ACBT	C3719ACBT	-1.		
P19ACBT	C1926ACBT	1.		
P19SAR	TSAR	1.	P19	1.
P19SAR	C1519SAR	-1.		

P19SAR	C1928SAR	1.		
P19NIGHT	TNIGHT	1.	P19	1.
P19COLS	TCOLS	1.	P19	1.
P20WD	TWD	1.	P20	1.
P20WD	C1720WD	-1.		
P20WD	C2024WD	1.		
P20SAT	TSAT	1.	P20	1.
P20SAT	C0420SAT	-1.		
P20SAT	C2025SAT	1.		
P20MAV	TMAV	1.	P20	1.
P20MAV	C2420MAV	-1.		
P20MAV	C2004MAV	1.		
P20ACBT	TACBT	1.	P20	1.
P20ACBT	C2420ACBT	-1.		
P20ACBT	C2011ACBT	1.		
P20SAR	TSAR	1.	P20	1.
P20SAR	C0420SAR	-1.		
P20SAR	C2015SAR	1.		
P20NIGHT	TNIGHT	1.	P20	1.
P20COLS	TCOLS	1.	P20	1.
P21WD	TWD	1.	P21	1.
P21SAT	TSAT	1.	P21	1.
P21MAV	TMAV	1.	P21	1.
P21ACBT	TACBT	1.	P21	1.
P21SAR	TSAR	1.	P21	1.
P21NIGHT	TNIGHT	1.	P21	1.
P21COLS	TCOLS	1.	P21	1.
P22WD	TWD	1.	P22	1.
P22SAT	TSAT	1.	P22	1.
P22MAV	TMAV	1.	P22	1.
P22ACBT	TACBT	1.	P22	1.
P22SAR	TSAR	1.	P22	1.
P22NIGHT	TNIGHT	1.	P22	1.
P22COLS	TCOLS	1.	P22	1.
P23WD	TWD	1.	P23	1.
P23SAT	TSAT	1.	P23	1.
P23SAT	C2309SAT	1.		
P23MAV	TMAV	1.	P23	1.
P23MAV	C3223MAV	-1.		
P23MAV	C2324MAV	1.		
P23ACBT	TACBT	1.	P23	1.
P23ACBT	C0923ACBT	-1.		
P23ACBT	C2312ACBT	1.		
P23SAR	TSAR	1.	P23	1.
P23SAR	C2309SAR	1.		
P23NIGHT	TNIGHT	1.	P23	1.
P23COLS	TCOLS	1.	P23	1.
P24WD	TWD	1.	P24	1.
P24WD	C2024WD	-1.		
P24WD	C2415WD	1.		
P24SAT	TSAT	1.	P24	1.
P24SAT	C3224SAT	-1.		
P24SAT	C2419SAT	1.		
P24MAV	TMAV	1.	P24	1.
P24MAV	C2324MAV	-1.		
P24MAV	C2420MAV	1.		
P24ACBT	TACBT	1.	P24	1.
P24ACBT	C2524ACBT	-1.		
P24ACBT	C2420ACBT	1.		
P24SAR	TSAR	1.	P24	1.
P24SAR	C2524SAR	-1.		
P24SAR	C2412SAR	1.		
P24NIGHT	TNIGHT	1.	P24	1.
P24COLS	TCOLS	1.	P24	1.
P25WD	TWD	1.	P25	1.
P25WD	C1525WD	-1.		

P25WD	C2524WD	1.		
P25SAT	TSAT	1.	P25	1.
P25SAT	C2025SAT	-1.		
P25SAT	C2510SAT	1.		
P25MAV	TMAV	1.	P25	1.
P25MAV	C1425MAV	-1.		
P25MAV	C2511MAV	1.		
P25ACBT	TACBT	1.	P25	1.
P25ACBT	C3625ACBT	-1.		
P25ACBT	C2524ACBT	1.		
P25SAR	TSAR	1.	P25	1.
P25SAR	C2525SAR	-1.		
P25SAR	C2524SAR	1.		
P25NIGHT	TNIGHT	1.	P25	1.
P25COLS	TCOLS	1.	P25	1.
P26WD	TWD	1.	P26	1.
P26WD	C2426WD	-1.		
P26WD	C2604WD	1.		
P26SAT	TSAT	1.	P26	1.
P26SAT	C1226SAT	-1.		
P26SAT	C2637SAT	1.		
6MAV	TMAV	1.	P26	1.
P26MAV	C1226MAV	-1.		
P26MAV	C2619MAV	1.		
P26ACBT	TACBT	1.	P26	1.
P26ACBT	C1426ACBT	-1.		
P26ACBT	C2606ACBT	1.		
P26SAR	TSAR	1.	P26	1.
P26SAR	C3626SAR	-1.		
P26SAR	C2632SAR	1.		
P26NIGHT	TNIGHT	1.	P26	1.
P26COLS	TCOLS	1.	P26	1.
P27WD	TWD	1.	P27	1.
P27SAT	TSAT	1.	P27	1.
P27MAV	TMAV	1.	P27	1.
P27ACBT	TACBT	1.	P27	1.
P27SAR	TSAR	1.	P27	1.
P27NIGHT	TNIGHT	1.	P27	1.
P27COLS	TCOLS	1.	P27	1.
P28WD	TWD	1.	P28	1.
P28WD	C1228WD	-1.		
P28WD	C2837WD	1.		
P28SAT	TSAT	1.	P28	1.
P28SAT	C2428SAT	-1.		
P28SAT	C2804SAT	1.		
P28MAV	TMAV	1.	P28	1.
P28MAV	C3728MAV	-1.		
P28MAV	C2812MAV	1.		
P28ACBT	TACBT	1.	P28	1.
P28ACBT	C1128ACBT	-1.		
P28SAR	TSAR	1.	P28	1.
P28SAR	C1428SAR	-1.		
P28SAR	C2825SAR	1.		
P28NIGHT	TNIGHT	1.	P28	1.
P28COLS	TCOLS	1.	P28	1.
P29WD	TWD	1.	P29	1.
P29WD	C2529WD	-1.		
P29WD	C2429WD	1.		
P29SAT	TSAT	1.	P29	1.
P29SAT	C0229SAT	-1.		
P29SAT	C2428SAT	1.		
P29MAV	TMAV	1.	P29	1.
P29MAV	C1429MAV	-1.		
P29MAV	C2932MAV	1.		
P29ACBT	TACBT	1.	P29	1.
P29ACBT	C3229ACBT	-1.		

P29ACBT	C2904ACBT	1.		
P29SAR	TSAR	1.	P29	1.
P29SAR	C0329SAR	-1.		
P29SAR	C2931SAR	1.		
P29NIGHT	TNIGHT	1.	P29	1.
P29COLS	TCOLS	1.	P29	1.
P30WD	TWD	1.	P30	1.
P30SAT	TSAT	1.	P30	1.
P30MAV	TMAV	1.	P30	1.
P30ACBT	TACBT	1.	P30	1.
P30SAR	TSAR	1.	P30	1.
P30NIGHT	TNIGHT	1.	P30	1.
P30COLS	TCOLS	1.	P30	1.
P31WD	TWD	1.	P31	1.
P31SAT	TSAT	1.	P31	1.
P31MAV	TMAV	1.	P31	1.
P31ACBT	TACBT	1.	P31	1.
P31SAR	TSAR	1.	P31	1.
P31SAR	C2931SAR	-1.		
P31SAR	C3113SAR	1.		
P31NIGHT	TNIGHT	1.	P31	1.
P31COLS	TCOLS	1.	P31	1.
P32WD	TWD	1.	P32	1.
P32WD	C0932WD	-1.		
P32WD	C3211WD	1.		
P32SAT	TSAT	1.	P32	1.
P32SAT	C1532SAT	-1.		
P32SAT	C3224SAT	1.		
P32MAV	TMAV	1.	P32	1.
P32MAV	C2432MAV	-1.		
P32MAV	C3223MAV	1.		
P32ACBT	TACBT	1.	P32	1.
P32ACBT	C1232ACBT	-1.		
P32ACBT	C3229ACBT	1.		
P32SAR	TSAR	1.	P32	1.
P32SAR	C2532SAR	-1.		
P32SAR	C3237SAR	1.		
P32NIGHT	TNIGHT	1.	P32	1.
P32COLS	TCOLS	1.	P32	1.
P33WD	TWD	1.	P33	1.
P33SAT	TSAT	1.	P33	1.
P33MAV	TMAV	1.	P33	1.
P33ACBT	TACBT	1.	P33	1.
P33SAR	TSAR	1.	P33	1.
P33SAR	C1533SAR	-1.		
P33SAR	C3303SAR	1.		
P33NIGHT	TNIGHT	1.	P33	1.
P33COLS	TCOLS	1.	P33	1.
P34WD	TWD	1.	P34	1.
P34SAT	TSAT	1.	P34	1.
P34MAV	TMAV	1.	P34	1.
P34ACBT	TACBT	1.	P34	1.
P34SAR	TSAR	1.	P34	1.
P34NIGHT	TNIGHT	1.	P34	1.
P34COLS	TCOLS	1.	P34	1.
P35WD	TWD	1.	P35	1.
P35WD	C0235WD	-1.		
P35WD	C3517WD	1.		
P35SAT	TSAT	1.	P35	1.
P35MAV	TMAV	1.	P35	1.
P35ACBT	TACBT	1.	P35	1.
P35SAR	TSAR	1.	P35	1.
P35NIGHT	TNIGHT	1.	P35	1.
P35COLS	TCOLS	1.	P35	1.
P36WD	TWD	1.	P36	1.
P36SAT	TSAT	1.	P36	1.

```
    P36MAV     TMAV       1.              P36        1.
    P36MAV     C3513MAV   1.
    P36ACBT    TACBT      1.              P36        1.
    P36ACBT    C0236ACBT  -1.
    P36ACBT    C3625ACBT  1.
    P36SAR     TSAR       1.              P36        1.
    P36SAR     C0636SAR   -1.
    P36SAR     C3626SAR   1.
    P36NIGHT   TNIGHT     1.              P36        1.
    P36COLS    TCOLS      1.              P36        1.
    P37WD      TWD        1.              P37        1.
    P37WD      C2837WD    -1.
    P37SAT     TSAT       1.              P37        1.
    P37SAT     C2637SAT   -1.
    P37SAT     C3715SAT   1.
    P37MAV     TMAV       1.              P37        1.
    P37MAV     C1537MAV   -1.
    P37MAV     C3728MAV   1.
    P37ACBT    TACBT      1.              P37        1.
    P37ACBT    C0537ACBT  -1.
    P37ACBT    C3719ACBT  1.
    P37SAR     TSAR       1.              P37        1.
    P37SAR     C3237SAR   -1.
    P37SAR     C3711SAR   1.
    P37NIGHT   TNIGHT     1.              P37        1.
    P37COLS    TCOLS      1.              P37        1.
RHS
    RHS        TWD        462
    RHS        TSAT       551
    RHS        TMAV       362
    RHS        TACBT      357
    RHS        TSAR       313
    RHS        TNIGHT     411
    RHS        TCOLS      522
    RHS        P01         39
    RHS        P02         97
    RHS        P03         89
    RHS        P04         97
    RHS        P05         76
    RHS        P06         89
    RHS        P07         89
    RHS        P08         39
    RHS        P09         76
    RHS        P10         97
    RHS        P11         97
    RHS        P12         97
    RHS        P13         81
    RHS        P14         39
    RHS        P15         97
    RHS        P16         81
    RHS        P17         57
    RHS        P18         69
    RHS        P19         97
    RHS        P20         97
    RHS        P21         65
    RHS        P22         57
    RHS        P23         76
    RHS        P24         97
    RHS        P25         97
    RHS        P26         97
    RHS        P27         39
    RHS        P28         97
    RHS        P29         97
    RHS        P30         62
    RHS        P31         89
    RHS        P32         97
```

RMS		P33	89	UI	BOUNDS	P02SAR	10
RMS		P34	57	LI	BOUNDS	P02SAW	5
RMS		P35	66	UI	BOUNDS	P02NIGHT	15
RMS		P36	76	LI	BOUNDS	P02NIGHT	6
RMS		P37	97	UI	BOUNDS	P02COLS	13
RANGES				LI	BOUNDS	P02COLS	8
RANGES		P01	9	UI	BOUNDS	P03WD	12
RANGES		P02	13	LI	BOUNDS	P03WD	9
RANGES		P03	12	UI	BOUNDS	P03SAT	13
RANGES		P04	13	LI	BOUNDS	P03SAT	10
RANGES		P05	7	UI	BOUNDS	P03MAV	10
RANGES		P06	12	LI	BOUNDS	P03MAV	9
RANGES		P07	12	UI	BOUNDS	P03ACBT	8
RANGES		P08	9	LI	BOUNDS	P03ACBT	6
RANGES		P09	7	UI	BOUNDS	P03SAW	11
RANGES		P10	13	LI	BOUNDS	P03SAR	8
RANGES		P11	13	UI	BOUNDS	P03NIGHT	11
RANGES		P12	13	LI	BOUNDS	P03NIGHT	6
RANGES		P13	6	UI	BOUNDS	P03COLS	25
RANGES		P14	12	LI	BOUNDS	P03COLS	19
RANGES		P15	13	UI	BOUNDS	P04WD	16
RANGES		P16	6	LI	BOUNDS	P04WD	14
RANGES		P17	12	UI	BOUNDS	P04SAT	18
RANGES		P18	12	LI	BOUNDS	P04SAT	15
RANGES		P19	13	UI	BOUNDS	P04MAV	12
RANGES		P20	13	LI	BOUNDS	P04MAV	10
RANGES		P21	6	UI	BOUNDS	P04ACBT	12
RANGES		P22	12	LI	BOUNDS	P04ACBT	8
RANGES		P23	7	UI	BOUNDS	P04SAW	10
RANGES		P24	13	LI	BOUNDS	P04SAR	5
RANGES		P25	13	UI	BOUNDS	P04NIGHT	15
RANGES		P26	13	LI	BOUNDS	P04NIGHT	6
RANGES		P27	9	UI	BOUNDS	P04COLS	13
RANGES		P28	13	LI	BOUNDS	P04COLS	8
RANGES		P29	13	UI	BOUNDS	P05WD	12
RANGES		P30	2	LI	BOUNDS	P05WD	8
RANGES		P31	12	UI	BOUNDS	P05SAT	13
RANGES		P32	13	LI	BOUNDS	P05SAT	9
RANGES		P33	12	UI	BOUNDS	P05MAV	10
RANGES		P34	12	LI	BOUNDS	P05MAV	8
RANGES		P35	16	UI	BOUNDS	P05ACBT	10
RANGES		P36	7	LI	BOUNDS	P05ACBT	4
RANGES		P37	13	UI	BOUNDS	P05SAW	11
BOUNDS				LI	BOUNDS	P05SAW	7
UI	BOUNDS	P01WD	6	UI	BOUNDS	P05NIGHT	11
LI	BOUNDS	P01WD	2	LI	BOUNDS	P05NIGHT	5
UI	BOUNDS	P01SAT	10	UI	BOUNDS	P05COLS	12
LI	BOUNDS	P01SAT	2	LI	BOUNDS	P05COLS	10
UI	BOUNDS	P01MAV	6	UI	BOUNDS	P06WD	12
LI	BOUNDS	P01MAV	2	LI	BOUNDS	P06WD	9
UI	BOUNDS	P01ACBT	5	UI	BOUNDS	P06SAT	13
LI	BOUNDS	P01ACBT	2	LI	BOUNDS	P06SAT	10
UI	BOUNDS	P01SAW	5	UI	BOUNDS	P06MAV	10
LI	BOUNDS	P01SAR	2	LI	BOUNDS	P06MAV	5
UI	BOUNDS	P01NIGHT	6	UI	BOUNDS	P06ACBT	8
LI	BOUNDS	P01NIGHT	2	LI	BOUNDS	P06ACBT	5
UI	BOUNDS	P01COLS	9	UI	BOUNDS	P06SAW	11
LI	BOUNDS	P01COLS	6	LI	BOUNDS	P06SAW	9
UI	BOUNDS	P02WD	16	UI	BOUNDS	P06NIGHT	11
LI	BOUNDS	P02WD	13	LI	BOUNDS	P06NIGHT	6
UI	BOUNDS	P02SAT	18	UI	BOUNDS	P06COLS	25
LI	BOUNDS	P02SAT	14	LI	BOUNDS	P06COLS	19
UI	BOUNDS	P02MAV	12	UI	BOUNDS	P07WD	12
LI	BOUNDS	P02MAV	12	LI	BOUNDS	P07WD	8
UI	BOUNDS	P02ACBT	12	UI	BOUNDS	P07SAT	13
LI	BOUNDS	P02ACBT	8	LI	BOUNDS	P07SAT	9

UI	BOUNDS	P07MAV	10
LI	BOUNDS	P07MAV	8
UI	BOUNDS	P07ACBT	8
LI	BOUNDS	P07ACBT	7
UI	BOUNDS	P07SAR	11
LI	BOUNDS	P07SAR	8
UI	BOUNDS	P07NIGHT	11
LI	BOUNDS	P07NIGHT	6
UI	BOUNDS	P07COLS	25
LI	BOUNDS	P07COLS	19
UI	BOUNDS	P08WO	6
LI	BOUNDS	P08WO	2
UI	BOUNDS	P08SAT	10
LI	BOUNDS	P08SAT	2
UI	BOUNDS	P08MAV	6
LI	BOUNDS	P08MAV	2
UI	BOUNDS	P08ACBT	6
LI	BOUNDS	P08ACBT	2
UI	BOUNDS	P08SAR	5
LI	BOUNDS	P08SAR	2
UI	BOUNDS	P08NIGHT	5
LI	BOUNDS	P08NIGHT	2
UI	BOUNDS	P08COLS	9
LI	BOUNDS	P08COLS	6
UI	BOUNDS	P09WO	12
LI	BOUNDS	P09WO	7
UI	BOUNDS	P09SAT	13
LI	BOUNDS	P09SAT	8
UI	BOUNDS	P09MAV	10
LI	BOUNDS	P09MAV	5
UI	BOUNDS	P09ACBT	10
LI	BOUNDS	P09ACBT	5
UI	BOUNDS	P09SAR	11
LI	BOUNDS	P09SAR	7
UI	BOUNDS	P09NIGHT	11
LI	BOUNDS	P09NIGHT	6
UI	BOUNDS	P09COLS	12
LI	BOUNDS	P09COLS	10
UI	BOUNDS	P10WO	16
LI	BOUNDS	P10WO	14
UI	BOUNDS	P10SAT	18
LI	BOUNDS	P10SAT	15
UI	BOUNDS	P10MAV	12
LI	BOUNDS	P10MAV	12
UI	BOUNDS	P10ACBT	12
LI	BOUNDS	P10ACBT	6
UI	BOUNDS	P10SAR	10
LI	BOUNDS	P10SAR	9
UI	BOUNDS	P10NIGHT	15
LI	BOUNDS	P10NIGHT	6
UI	BOUNDS	P10COLS	13
LI	BOUNDS	P10COLS	8
UI	BOUNDS	P11WO	16
LI	BOUNDS	P11WO	13
UI	BOUNDS	P11SAT	18
LI	BOUNDS	P11SAT	13
UI	BOUNDS	P11MAV	12
LI	BOUNDS	P11MAV	11
UI	BOUNDS	P11ACBT	12
LI	BOUNDS	P11ACBT	9
UI	BOUNDS	P11SAR	10
LI	BOUNDS	P11SAR	8
UI	BOUNDS	P11NIGHT	15
LI	BOUNDS	P11NIGHT	6
UI	BOUNDS	P11COLS	13
LI	BOUNDS	P11COLS	8
UI	BOUNDS	P12WO	16
LI	BOUNDS	P12WO	15
UI	BOUNDS	P12SAT	18
LI	BOUNDS	P12SAT	16
UI	BOUNDS	P12MAV	12
LI	BOUNDS	P12MAV	10
UI	BOUNDS	P12ACBT	12
LI	BOUNDS	P12ACBT	8
UI	BOUNDS	P12SAR	10
LI	BOUNDS	P12SAR	9
UI	BOUNDS	P12NIGHT	15
LI	BOUNDS	P12NIGHT	5
UI	BOUNDS	P12COLS	13
LI	BOUNDS	P12COLS	8
UI	BOUNDS	P13WO	11
LI	BOUNDS	P13WO	9
UI	BOUNDS	P13SAT	12
LI	BOUNDS	P13SAT	7
UI	BOUNDS	P13MAV	9
LI	BOUNDS	P13MAV	5
UI	BOUNDS	P13ACBT	7
LI	BOUNDS	P13ACBT	2
UI	BOUNDS	P13SAR	9
LI	BOUNDS	P13SAR	7
UI	BOUNDS	P13NIGHT	10
LI	BOUNDS	P13NIGHT	5
UI	BOUNDS	P13COLS	22
LI	BOUNDS	P13COLS	17
UI	BOUNDS	P14WO	12
LI	BOUNDS	P14WO	7
UI	BOUNDS	P14SAT	13
LI	BOUNDS	P14SAT	9
UI	BOUNDS	P14MAV	10
LI	BOUNDS	P14MAV	5
UI	BOUNDS	P14ACBT	8
LI	BOUNDS	P14ACBT	7
UI	BOUNDS	P14SAR	11
LI	BOUNDS	P14SAR	7
UI	BOUNDS	P14NIGHT	11
LI	BOUNDS	P14NIGHT	6
UI	BOUNDS	P14COLS	25
LI	BOUNDS	P14COLS	19
UI	BOUNDS	P15WO	15
LI	BOUNDS	P15WO	14
UI	BOUNDS	P15SAT	18
LI	BOUNDS	P15SAT	15
UI	BOUNDS	P15MAV	12
LI	BOUNDS	P15MAV	10
UI	BOUNDS	P15ACBT	12
LI	BOUNDS	P15ACBT	8
UI	BOUNDS	P15SAR	10
LI	BOUNDS	P15SAR	8
UI	BOUNDS	P15NIGHT	15
LI	BOUNDS	P15NIGHT	5
UI	BOUNDS	P15COLS	13
LI	BOUNDS	P15COLS	8
UI	BOUNDS	P16WO	11
LI	BOUNDS	P16WO	6
UI	BOUNDS	P16SAT	12
LI	BOUNDS	P16SAT	7
UI	BOUNDS	P16MAV	9
LI	BOUNDS	P16MAV	7
UI	BOUNDS	P16ACBT	7
LI	BOUNDS	P16ACBT	4
UI	BOUNDS	P16SAR	9
LI	BOUNDS	P16SAR	5

UI	BOUNDS	P16NIGHT	10
LI	BOUNDS	P16NIGHT	5
UI	BOUNDS	P16COLS	22
LI	BOUNDS	P16COLS	17
UI	BOUNDS	P17WD	13
LI	BOUNDS	P17WD	10
UI	BOUNDS	P17SAT	7
LI	BOUNDS	P17SAT	4
UI	BOUNDS	P17MAV	5
LI	BOUNDS	P17MAV	3
UI	BOUNDS	P17ACBT	6
LI	BOUNDS	P17ACBT	6
UI	BOUNDS	P17SAR	5
LI	BOUNDS	P17SAR	3
UI	BOUNDS	P17NIGHT	4
LI	BOUNDS	P17NIGHT	2
UI	BOUNDS	P17COLS	18
LI	BOUNDS	P17COLS	12
UI	BOUNDS	P18WD	12
LI	BOUNDS	P18WD	10
UI	BOUNDS	P18SAT	13
LI	BOUNDS	P18SAT	8
UI	BOUNDS	P18MAV	10
LI	BOUNDS	P18MAV	7
UI	BOUNDS	P18ACBT	8
LI	BOUNDS	P18ACBT	4
UI	BOUNDS	P18SAR	11
LI	BOUNDS	P18SAR	8
UI	BOUNDS	P18NIGHT	11
LI	BOUNDS	P18NIGHT	6
UI	BOUNDS	P18COLS	25
LI	BOUNDS	P18COLS	19
UI	BOUNDS	P19WD	16
LI	BOUNDS	P19WD	13
UI	BOUNDS	P19SAT	18
LI	BOUNDS	P19SAT	17
UI	BOUNDS	P19MAV	12
LI	BOUNDS	P19MAV	11
UI	BOUNDS	P19ACBT	12
LI	BOUNDS	P19ACBT	7
UI	BOUNDS	P19SAR	10
LI	BOUNDS	P19SAR	8
UI	BOUNDS	P19NIGHT	15
LI	BOUNDS	P19NIGHT	5
UI	BOUNDS	P19COLS	13
LI	BOUNDS	P19COLS	8
UI	BOUNDS	P20WD	16
LI	BOUNDS	P20WD	14
UI	BOUNDS	P20SAT	18
LI	BOUNDS	P20SAT	15
UI	BOUNDS	P20MAV	12
LI	BOUNDS	P20MAV	10
UI	BOUNDS	P20ACBT	12
LI	BOUNDS	P20ACBT	9
UI	BOUNDS	P20SAR	10
LI	BOUNDS	P20SAR	8
UI	BOUNDS	P20NIGHT	15
LI	BOUNDS	P20NIGHT	6
UI	BOUNDS	P20COLS	13
LI	BOUNDS	P20COLS	8
UI	BOUNDS	P21WD	11
LI	BOUNDS	P21WD	10
UI	BOUNDS	P21SAT	12
LI	BOUNDS	P21SAT	8
UI	BOUNDS	P21MAV	9
LI	BOUNDS	P21MAV	8
UI	BOUNDS	P21ACBT	7
LI	BOUNDS	P21ACBT	5
UI	BOUNDS	P21SAR	9
LI	BOUNDS	P21SAR	9
UI	BOUNDS	P21NIGHT	10
LI	BOUNDS	P21NIGHT	5
UI	BOUNDS	P21COLS	11
LI	BOUNDS	P21COLS	9
UI	BOUNDS	P22WD	13
LI	BOUNDS	P22WD	10
UI	BOUNDS	P22SAT	7
LI	BOUNDS	P22SAT	4
UI	BOUNDS	P22MAV	5
LI	BOUNDS	P22MAV	3
UI	BOUNDS	P22ACBT	6
LI	BOUNDS	P22ACBT	6
UI	BOUNDS	P22SAR	6
LI	BOUNDS	P22SAR	3
UI	BOUNDS	P22NIGHT	4
LI	BOUNDS	P22NIGHT	2
UI	BOUNDS	P22COLS	18
LI	BOUNDS	P22COLS	12
UI	BOUNDS	P23WD	12
LI	BOUNDS	P23WD	8
UI	BOUNDS	P23SAT	13
LI	BOUNDS	P23SAT	9
UI	BOUNDS	P23MAV	10
LI	BOUNDS	P23MAV	7
UI	BOUNDS	P23ACBT	10
LI	BOUNDS	P23ACBT	5
UI	BOUNDS	P23SAR	11
LI	BOUNDS	P23SAR	7
UI	BOUNDS	P23NIGHT	11
LI	BOUNDS	P23NIGHT	5
UI	BOUNDS	P23COLS	12
LI	BOUNDS	P23COLS	10
UI	BOUNDS	P24WD	16
LI	BOUNDS	P24WD	14
UI	BOUNDS	P24SAT	18
LI	BOUNDS	P24SAT	17
UI	BOUNDS	P24MAV	12
LI	BOUNDS	P24MAV	9
UI	BOUNDS	P24ACBT	12
LI	BOUNDS	P24ACBT	8
UI	BOUNDS	P24SAR	10
LI	BOUNDS	P24SAR	9
UI	BOUNDS	P24NIGHT	15
LI	BOUNDS	P24NIGHT	5
UI	BOUNDS	P24COLS	13
LI	BOUNDS	P24COLS	8
UI	BOUNDS	P25WD	16
LI	BOUNDS	P25WD	14
UI	BOUNDS	P25SAT	18
LI	BOUNDS	P25SAT	15
UI	BOUNDS	P25MAV	12
LI	BOUNDS	P25MAV	11
UI	BOUNDS	P25ACBT	12
LI	BOUNDS	P25ACBT	8
UI	BOUNDS	P25SAR	10
LI	BOUNDS	P25SAR	8
UI	BOUNDS	P25NIGHT	15
LI	BOUNDS	P25NIGHT	6
UI	BOUNDS	P25COLS	13
LI	BOUNDS	P25COLS	8
UI	BOUNDS	P25WD	16
LI	BOUNDS	P26WD	14

UI	BOUNDS	P26SAT	18
LI	BOUNDS	P26SAT	16
UI	BOUNDS	P26MAV	12
LI	BOUNDS	P26MAV	10
UI	BOUNDS	P26ACBT	12
LI	BOUNDS	P26ACBT	7
UI	BOUNDS	P26SAR	10
LI	BOUNDS	P26SAR	8
UI	BOUNDS	P26NIGHT	15
LI	BOUNDS	P26NIGHT	6
UI	BOUNDS	P26COLS	13
LI	BOUNDS	P26COLS	8
UI	BOUNDS	P27WD	6
LI	BOUNDS	P27WD	2
UI	BOUNDS	P27SAT	10
LI	BOUNDS	P27SAT	2
UI	BOUNDS	P27MAV	6
LI	BOUNDS	P27MAV	2
UI	BOUNDS	P27ACBT	6
LI	BOUNDS	P27ACBT	2
UI	BOUNDS	P27SAR	5
LI	BOUNDS	P27SAR	2
UI	BOUNDS	P27NIGHT	6
LI	BOUNDS	P27NIGHT	2
UI	BOUNDS	P27COLS	9
LI	BOUNDS	P27COLS	5
UI	BOUNDS	P28WD	16
LI	BOUNDS	P28WD	15
UI	BOUNDS	P28SAT	18
LI	BOUNDS	P28SAT	15
UI	BOUNDS	P28MAV	12
LI	BOUNDS	P28MAV	10
UI	BOUNDS	P28ACBT	12
LI	BOUNDS	P28ACBT	9
UI	BOUNDS	P28SAR	10
LI	BOUNDS	P28SAR	8
UI	BOUNDS	P28NIGHT	15
LI	BOUNDS	P28NIGHT	6
UI	BOUNDS	P28COLS	13
LI	BOUNDS	P28COLS	8
UI	BOUNDS	P29WD	16
LI	BOUNDS	P29WD	14
UI	BOUNDS	P29SAT	18
LI	BOUNDS	P29SAT	14
UI	BOUNDS	P29MAV	12
LI	BOUNDS	P29MAV	9
UI	BOUNDS	P29ACBT	12
LI	BOUNDS	P29ACBT	5
UI	BOUNDS	P29SAR	10
LI	BOUNDS	P29SAR	7
UI	BOUNDS	P29NIGHT	15
LI	BOUNDS	P29NIGHT	5
UI	BOUNDS	P29COLS	13
LI	BOUNDS	P29COLS	8
UI	BOUNDS	P30WD	15
LI	BOUNDS	P30WD	9
UI	BOUNDS	P30SAT	10
LI	BOUNDS	P30SAT	7
UI	BOUNDS	P30MAV	5
LI	BOUNDS	P30MAV	4
UI	BOUNDS	P30ACBT	6
LI	BOUNDS	P30ACBT	3
UI	BOUNDS	P30SAR	5
LI	BOUNDS	P30SAR	3
UI	BOUNDS	P30NIGHT	3
LI	BOUNDS	P30NIGHT	2
UI	BOUNDS	P30COLS	16
LI	BOUNDS	P30COLS	10
UI	BOUNDS	P31WD	12
LI	BOUNDS	P31WD	8
UI	BOUNDS	P31SAT	13
LI	BOUNDS	P31SAT	9
UI	BOUNDS	P31MAV	10
LI	BOUNDS	P31MAV	9
UI	BOUNDS	P31ACBT	8
LI	BOUNDS	P31ACBT	6
UI	BOUNDS	P31SAR	11
LI	BOUNDS	P31SAR	8
UI	BOUNDS	P31NIGHT	11
LI	BOUNDS	P31NIGHT	5
UI	BOUNDS	P31COLS	25
LI	BOUNDS	P31COLS	19
UI	BOUNDS	P32WD	16
LI	BOUNDS	P32WD	12
UI	BOUNDS	P32SAT	18
LI	BOUNDS	P32SAT	17
UI	BOUNDS	P32MAV	12
LI	BOUNDS	P32MAV	9
UI	BOUNDS	P32ACBT	12
LI	BOUNDS	P32ACBT	8
UI	BOUNDS	P32SAR	10
LI	BOUNDS	P32SAR	8
UI	BOUNDS	P32NIGHT	15
LI	BOUNDS	P32NIGHT	5
UI	BOUNDS	P32COLS	13
LI	BOUNDS	P32COLS	5
UI	BOUNDS	P33WD	12
LI	BOUNDS	P33WD	9
UI	BOUNDS	P33SAT	13
LI	BOUNDS	P33SAT	9
UI	BOUNDS	P33MAV	10
LI	BOUNDS	P33MAV	8
UI	BOUNDS	P33ACBT	8
LI	BOUNDS	P33ACBT	6
UI	BOUNDS	P33SAR	11
LI	BOUNDS	P33SAR	5
UI	BOUNDS	P33NIGHT	11
LI	BOUNDS	P33NIGHT	6
UI	BOUNDS	P33COLS	25
LI	BOUNDS	P33COLS	19
UI	BOUNDS	P34WD	13
LI	BOUNDS	P34WD	10
UI	BOUNDS	P34SAT	7
LI	BOUNDS	P34SAT	4
UI	BOUNDS	P34MAV	5
LI	BOUNDS	P34MAV	3
UI	BOUNDS	P34ACBT	6
LI	BOUNDS	P34ACBT	5
UI	BOUNDS	P34SAR	6
LI	BOUNDS	P34SAR	3
UI	BOUNDS	P34NIGHT	4
LI	BOUNDS	P34NIGHT	2
UI	BOUNDS	P34COLS	18
LI	BOUNDS	P34COLS	12
UI	BOUNDS	P35WD	16
LI	BOUNDS	P35WD	10
UI	BOUNDS	P35SAT	12
LI	BOUNDS	P35SAT	9
UI	BOUNDS	P35MAV	7
LI	BOUNDS	P35MAV	5
UI	BOUNDS	P35ACBT	7
LI	BOUNDS	P35ACBT	4

```
UI BOUNDS    P35SAW       5
LI BOUNDS    P35SAW       3
UI BOUNDS    P35NIGHT     3
LI BOUNDS    P35NIGHT     2
UI BOUNDS    P35COLS     13
LI BOUNDS    P35COLS      4
UI BOUNDS    P36WD       12
LI BOUNDS    P36WD       10
UI BOUNDS    P36SAT      13
LI BOUNDS    P36SAT      10
UI BOUNDS    P36MAV      10
LI BOUNDS    P36MAV       5
UI BOUNDS    P36ACBT     10
LI BOUNDS    P36ACBT      6
UI BOUNDS    P36SAW      11
LI BOUNDS    P36SAW       4
UI BOUNDS    P36NIGHT    11
LI BOUNDS    P36NIGHT     5
UI BOUNDS    P36COLS     12
LI BOUNDS    P36COLS     10
UI BOUNDS    P37WD       16
LI BOUNDS    P37WD       15
UI BOUNDS    P37SAT      16
LI BOUNDS    P37SAT      16
UI BOUNDS    P37MAV      12
LI BOUNDS    P37MAV      10
UI BOUNDS    P37ACBT     12
LI BOUNDS    P37ACBT      7
UI BOUNDS    P37SAW      10
LI BOUNDS    P37SAW       5
UI BOUNDS    P37NIGHT    15
LI BOUNDS    P37NIGHT     6
UI BOUNDS    P37COLS     13
LI BOUNDS    P37COLS      6
ENDATA
```

APPENDIX F

APPENDIX F

COMPUTER SOLUTION

The computer print-out in this appendix is the result of running the CDC APEX III package with the input from Appendix E. The print-out includes both a minimum and maximum solution. Specific guidance on interpreting the print-out is found in Chapter III and Appendix E.

C O L U M N S

PRINT OPTION = FULL MAP NAME = SPECIALZRO? = NO VALUE OF OBJECTIVE = 2619.00000
NAME = PANNELL OUT = TOTALS RHS = RHS BND = BOUNDS RPSOBJ = 1.0000 RPSRHS = 1.0000
DIR = MINIMIZE COST = RNG = RANGES RPCOBJ = 0.0000 RPCRHS = 0.0000

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COST	BND LOWER	BND UPPER	MARGINAL
1	P01WD	INI	** LOWER	2.00000	1.00000	2.00000	6.00000	.
2	P01SAT	INI	** LOWER	2.00000	1.00000	2.00000	10.00000	.
3	P01MAV	INI	ACTIVE	6.00000	1.00000	2.00000	6.00000	.
4	P01ACHT	INI	** UPPER	6.00000	1.00000	2.00000	6.00000	.
5	P01SAN	INI	** LOWER	2.00000	1.00000	2.00000	5.00000	.
6	P01NIGHT	INI	** UPPER	6.00000	1.00000	2.00000	6.00000	.
7	P01COLS	INI	** LOWER	6.00000	1.00000	6.00000	9.00000	.
8	P02WD	INI	** LOWER	13.00000	1.00000	13.00000	16.00000	.
9	P02SAT	INI	** LOWER	14.00000	1.00000	14.00000	18.00000	.
10	P02MAV	UEX	** LOWER	12.00000	1.00000	12.00000	12.00000	.
11	P02ACHT	INI	** LOWER	8.00000	1.00000	8.00000	12.00000	.
12	P02SAN	INI	ACTIVE	9.00000	1.00000	8.00000	10.00000	.
13	P02NIGHT	INI	ACTIVE	15.00000	1.00000	6.00000	15.00000	.
14	P02COLS	INI	** UPPER	13.00000	1.00000	8.00000	13.00000	.
15	P03WD	INI	** LOWER	9.00000	1.00000	9.00000	12.00000	.
16	P03SAT	INI	** LOWER	10.00000	1.00000	10.00000	13.00000	.
17	P03MAV	INI	** LOWER	9.00000	1.00000	9.00000	10.00000	.
18	P03ACHT	INI	** UPPER	8.00000	1.00000	6.00000	8.00000	.
19	P03SAN	INI	** LOWER	8.00000	1.00000	8.00000	11.00000	.
20	P03NIGHT	INI	ACTIVE	8.00000	1.00000	6.00000	11.00000	.
21	P03COLS	INI	** UPPER	25.00000	1.00000	19.00000	25.00000	.
22	P04WD	INI	** UPPER	16.00000	1.00000	14.00000	16.00000	.
23	P04SAT	INI	ACTIVE	16.00000	1.00000	15.00000	18.00000	.
24	P04MAV	INI	ACTIVE	10.00000	1.00000	10.00000	12.00000	.
25	P04ACHT	INI	ACTIVE	8.00000	1.00000	8.00000	12.00000	.
26	P04SAN	INI	ACTIVE	9.00000	1.00000	8.00000	10.00000	.
27	P04NIGHT	INI	** UPPER	15.00000	1.00000	6.00000	15.00000	.
28	P04COLS	INI	ACTIVE	10.00000	1.00000	8.00000	13.00000	.
29	P05WD	INI	** LOWER	8.00000	1.00000	8.00000	12.00000	.
30	P05SAT	INI	** UPPER	13.00000	1.00000	9.00000	13.00000	.
31	P05MAV	INI	** UPPER	10.00000	1.00000	8.00000	10.00000	.
32	P05ACHT	INI	ACTIVE	7.00000	1.00000	4.00000	10.00000	.
33	P05SAN	INI	ACTIVE	8.00000	1.00000	7.00000	11.00000	.
34	P05NIGHT	INI	** UPPER	11.00000	1.00000	6.00000	11.00000	.
35	P05COLS	INI	** UPPER	12.00000	1.00000	10.00000	12.00000	.
36	P06WD	INI	** LOWER	9.00000	1.00000	9.00000	12.00000	.
37	P06SAT	INI	** LOWER	10.00000	1.00000	10.00000	13.00000	.
38	P06MAV	INI	** LOWER	8.00000	1.00000	8.00000	10.00000	.
39	P06ACHT	INI	** UPPER	8.00000	1.00000	5.00000	8.00000	.
40	P06SAN	INI	** LOWER	9.00000	1.00000	9.00000	11.00000	.
41	P06NIGHT	INI	ACTIVE	8.00000	1.00000	6.00000	11.00000	.
42	P06COLS	INI	** UPPER	25.00000	1.00000	19.00000	25.00000	.
43	P07WD	INI	** UPPER	12.00000	1.00000	8.00000	12.00000	.
44	P07SAT	INI	** UPPER	13.00000	1.00000	9.00000	13.00000	.
45	P07MAV	INI	** UPPER	10.00000	1.00000	8.00000	10.00000	.
46	P07ACHT	INI	** UPPER	8.00000	1.00000	7.00000	8.00000	.
47	P07SAN	INI	ACTIVE	8.00000	1.00000	8.00000	11.00000	.
48	P07NIGHT	INI	** LOWER	6.00000	1.00000	6.00000	11.00000	.
49	P07COLS	INI	ACTIVE	20.00000	1.00000	19.00000	25.00000	.
50	P08WD	INI	** LOWER	2.00000	1.00000	2.00000	6.00000	.

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
51	C1902WD	LE	SLACK	.	.	-INF	.	.
52	C0235WD	LE	** BINDING	.	.	-INF	.	.
53	C3517WD	LE	** BINDING	.	.	-INF	.	.
54	C1720WD	LE	SLACK	-1.00000	1.00000	-INF	.	.
55	C2024WD	LE	SLACK	.	.	-INF	.	.
56	C2415WD	LE	** BINDING	.	.	-INF	.	.
57	C1525WD	LE	** BINDING	.	.	-INF	.	.
58	C2529WD	LE	SLACK	.	.	-INF	.	.
59	C2926WD	LE	SLACK	.	.	-INF	.	.
60	C2604WD	LE	SLACK	-2.00000	2.00000	-INF	.	.
61	C0410WD	LE	SLACK	.	.	-INF	.	.
62	C1012WD	LE	SLACK	.	.	-INF	.	.
63	C1228WD	LE	SLACK	.	.	-INF	.	.
64	C2837WD	LE	SLACK	.	.	-INF	.	.
65	C2309SAT	LE	SLACK	-1.00000	1.00000	-INF	.	.
66	C0916SAT	LE	SLACK	.	.	-INF	.	.
67	C1813SAT	LE	SLACK	-1.00000	1.00000	-INF	.	.
68	C1102SAT	LE	** BINDING	.	.	-INF	.	.
69	C0229SAT	LE	SLACK	-2.00000	2.00000	-INF	.	.
70	C2928SAT	LE	SLACK	.	.	-INF	.	.
71	C2804SAT	LE	** BINDING	.	.	-INF	.	.
72	C0420SAT	LE	** BINDING	.	.	-INF	.	.
73	C2025SAT	LE	** BINDING	.	.	-INF	.	.
74	C2510SAT	LE	** BINDING	.	.	-INF	.	.
75	C1012SAT	LE	** BINDING	.	.	-INF	.	.
76	C1226SAT	LE	** BINDING	.	.	-INF	.	.
77	C2637SAT	LE	SLACK	-1.00000	1.00000	-INF	.	.
78	C1715SAT	LE	** BINDING	.	.	-INF	.	.
79	C1532SAT	LE	** BINDING	.	.	-INF	.	.
80	C1224SAT	LE	** BINDING	.	.	-INF	.	.
81	C2419SAT	LE	** BINDING	.	.	-INF	.	.
82	C3613MAV	LE	** BINDING	.	.	-INF	.	.
83	C1109MAV	LE	SLACK	-4.00000	4.00000	-INF	.	.
84	C0914MAV	LE	** BINDING	.	.	-INF	.	.
85	C1418MAV	LE	** BINDING	.	.	-INF	.	.
86	C1829MAV	LE	** BINDING	.	.	-INF	.	.
87	C2932MAV	LE	SLACK	.	.	-INF	.	.
88	C3223MAV	LE	** BINDING	.	.	-INF	.	.
89	C2324MAV	LE	SLACK	.	.	-INF	.	.
90	C2420MAV	LE	** BINDING	.	.	-INF	.	.
91	C2004MAV	LE	SLACK	.	.	-INF	.	.
92	C0415MAV	LE	** BINDING	.	.	-INF	.	.
93	C1537MAV	LE	SLACK	.	.	-INF	.	.
94	C1728MAV	LE	** BINDING	.	.	-INF	.	.
95	C2612MAV	LE	** BINDING	.	.	-INF	.	.
96	C1226MAV	LE	** BINDING	.	.	-INF	.	.
97	C2619MAV	LE	SLACK	-1.00000	1.00000	-INF	.	.
98	C1925MAV	LE	SLACK	-1.00000	1.00000	-INF	.	.
99	C2511MAV	LE	** BINDING	.	.	-INF	.	.
100	C1110MAV	LE	SLACK	.	.	-INF	.	.

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
101	C1018ACHI	LE	** BINDING	.	.	-INF	.	.
102	C1813ACHI	LE	SLACK	.	.	-INF	.	.
103	C1305ACHI	LE	SLACK	.	.	-INF	.	.
104	C0537ACHI	LE	SLACK	.	.	-INF	.	.
105	C1719ACHI	LE	** BINDING	.	.	-INF	.	.
106	C1726ACHI	LE	** BINDING	.	.	-INF	.	.
107	C2606ACHI	LE	SLACK	-1.00000	1.00000	-INF	.	.
108	C0609ACHI	LE	SLACK	.	.	-INF	.	.
109	C0923ACHI	LE	** BINDING	.	.	-INF	.	.
110	C2112ACHI	LE	** BINDING	.	.	-INF	.	.
111	C1232ACHI	LE	** BINDING	.	.	-INF	.	.
112	C3229ACHI	LE	** BINDING	.	.	-INF	.	.
113	C2904ACHI	LE	** BINDING	.	.	-INF	.	.
114	C0415ACHI	LE	** BINDING	.	.	-INF	.	.
115	C1502ACHI	LE	SLACK	.	.	-INF	.	.
116	C0236ACHI	LE	SLACK	-1.00000	1.00000	-INF	.	.
117	C1625ACHI	LE	** BINDING	.	.	-INF	.	.
118	C2524ACHI	LE	** BINDING	.	.	-INF	.	.
119	C2420ACHI	LE	** BINDING	.	.	-INF	.	.
120	C2011ACHI	LE	SLACK	.	.	-INF	.	.
121	C1128ACHI	LE	SLACK	-1.00000	1.00000	-INF	.	.
122	C2309SAM	LE	** BINDING	.	.	-INF	.	.
123	C0905SAM	LE	** BINDING	.	.	-INF	.	.
124	C0514SAM	LE	** BINDING	.	.	-INF	.	.
125	C1407SAM	LE	** BINDING	.	.	-INF	.	.
126	C0718SAM	LE	** BINDING	.	.	-INF	.	.
127	C1816SAM	LE	** BINDING	.	.	-INF	.	.
128	C1633SAM	LE	** BINDING	.	.	-INF	.	.
129	C3103SAM	LE	** BINDING	.	.	-INF	.	.
130	C0329SAM	LE	SLACK	.	.	-INF	.	.
131	C2931SAM	LE	** BINDING	.	.	-INF	.	.
132	C3113SAM	LE	SLACK	-1.00000	1.00000	-INF	.	.
133	C1306SAM	LE	SLACK	.	.	-INF	.	.
134	C0636SAM	LE	SLACK	.	.	-INF	.	.
135	C1626SAM	LE	** BINDING	.	.	-INF	.	.
136	C2632SAM	LE	** BINDING	.	.	-INF	.	.
137	C3237SAM	LE	** BINDING	.	.	-INF	.	.
138	C3711SAM	LE	** BINDING	.	.	-INF	.	.
139	C1102SAM	LE	** BINDING	.	.	-INF	.	.
140	C0204SAM	LE	** BINDING	.	.	-INF	.	.
141	C0420SAM	LE	** BINDING	.	.	-INF	.	.
142	C2015SAM	LE	** BINDING	.	.	-INF	.	.
143	C1519SAM	LE	** BINDING	.	.	-INF	.	.
144	C1928SAM	LE	SLACK	-1.00000	1.00000	-INF	.	.
145	C2425SAM	LE	SLACK	.	.	-INF	.	.
146	C2624SAM	LE	SLACK	.	.	-INF	.	.
147	C2412SAM	LE	SLACK	.	.	-INF	.	.
148	C1210SAM	LE	SLACK	.	.	-INF	.	.

C O N S T R A I N T S

PRINT OPTION = FULL MAP NAME = SPECIAL/ROWS = NO VALUE OF OBJECTIVE = 2619.00000
NAME = PANNELL OBJ = TOTALS RHS = RHS BND = BOUNDS RPSOBJ = 1.0000 EPSRHS = 1.0000
DIR = MINIMIZE COLS = COLS = RNG = RANGES UPCOBJ = 0.0000 UPCRHS = 0.0000

NUMBER	ROW	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
1	TWO	LE	SLACK	413.00000	49.00000	-INF	462.00000	.
2	TSAT	LE	SLACK	461.00000	90.00000	-INF	551.00000	.
3	TNAV	LE	SLACK	325.00000	37.00000	-INF	362.00000	.
4	TACUT	LE	SLACK	273.00000	84.00000	-INF	357.00000	.
5	TSAR	LE	SLACK	279.00000	34.00000	-INF	313.00000	.
6	TNIGHT	LE	SLACK	366.00000	45.00000	-INF	411.00000	.
7	TCOLS	LE	SLACK	502.00000	20.00000	-INF	522.00000	.
8	TOTALS	FR	SLACK	2619.00000	-2619.00000	-INF	+INF	.
9	P01	ULE	BINDING	30.00000	9.00000	30.00000	39.00000	-1.00000
10	P02	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
11	P03	ULE	BINDING	77.00000	12.00000	77.00000	89.00000	-1.00000
12	P04	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
13	P05	ULE	BINDING	69.00000	7.00000	69.00000	76.00000	-1.00000
14	P06	ULE	BINDING	77.00000	12.00000	77.00000	89.00000	-1.00000
15	P07	ULE	BINDING	77.00000	12.00000	77.00000	89.00000	-1.00000
16	P08	ULE	BINDING	30.00000	9.00000	30.00000	39.00000	-1.00000
17	P09	ULE	BINDING	69.00000	7.00000	69.00000	76.00000	-1.00000
18	P10	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
19	P11	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
20	P12	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
21	P13	ULE	BINDING	75.00000	6.00000	75.00000	81.00000	-1.00000
22	P14	ULE	BINDING	77.00000	12.00000	77.00000	89.00000	-1.00000
23	P15	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
24	P16	ULE	BINDING	75.00000	6.00000	75.00000	81.00000	-1.00000
25	P17	ULE	BINDING	45.00000	12.00000	45.00000	57.00000	-1.00000
26	P18	ULE	BINDING	77.00000	12.00000	77.00000	89.00000	-1.00000
27	P19	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
28	P20	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
29	P21	ULE	BINDING	59.00000	6.00000	59.00000	65.00000	-1.00000
30	P22	ULE	BINDING	45.00000	12.00000	45.00000	57.00000	-1.00000
31	P23	ULE	BINDING	69.00000	7.00000	69.00000	76.00000	-1.00000
32	P24	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
33	P25	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
34	P26	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
35	P27	ULE	BINDING	30.00000	9.00000	30.00000	39.00000	-1.00000
36	P28	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
37	P29	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
38	P30	ULE	BINDING	60.00000	2.00000	60.00000	62.00000	-1.00000
39	P31	ULE	BINDING	77.00000	12.00000	77.00000	89.00000	-1.00000
40	P32	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
41	P33	ULE	BINDING	77.00000	12.00000	77.00000	89.00000	-1.00000
42	P34	ULE	BINDING	45.00000	12.00000	45.00000	57.00000	-1.00000
43	P35	ULE	BINDING	50.00000	16.00000	50.00000	66.00000	-1.00000
44	P36	ULE	BINDING	69.00000	7.00000	69.00000	76.00000	-1.00000
45	P37	ULE	BINDING	84.00000	13.00000	84.00000	97.00000	-1.00000
46	C1416WD	LE	** BINDING	.	.	-INF	.	.
47	C1609WD	LE	** BINDING	.	.	-INF	.	.
48	C0932WD	LE	SLACK	-6.00000	6.00000	-INF	.	.
49	C1211WD	LE	** BINDING	.	.	-INF	.	.
50	C1119WD	LE	SLACK	.	.	-INF	.	.

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
51	P08SAT	INT	ACTIVE	6.00000	1.00000	2.00000	10.00000	.
52	P08MAV	INT **	UPPER	6.00000	1.00000	2.00000	6.00000	.
53	P08ACHT	INT **	UPPER	6.00000	1.00000	2.00000	6.00000	.
54	P08SAR	INT **	LOWER	2.00000	1.00000	2.00000	5.00000	.
55	P08NIGHT	INT **	LOWER	2.00000	1.00000	2.00000	6.00000	.
56	P08COLS	INT **	LOWER	6.00000	1.00000	6.00000	9.00000	.
57	P09WD	INT	ACTIVE	7.00000	1.00000	7.00000	12.00000	.
58	P09SAT	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
59	P09MAV	INT **	UPPER	10.00000	1.00000	6.00000	10.00000	.
60	P09ACHT	INT	ACTIVE	8.00000	1.00000	5.00000	10.00000	.
61	P09SAR	INT	ACTIVE	8.00000	1.00000	7.00000	11.00000	.
62	P09NIGHT	INT **	UPPER	11.00000	1.00000	6.00000	11.00000	.
63	P09COLS	INT **	UPPER	12.00000	1.00000	10.00000	12.00000	.
64	P10WD	INT **	UPPER	16.00000	1.00000	14.00000	16.00000	.
65	P10SAT	INT	ACTIVE	16.00000	1.00000	15.00000	18.00000	.
66	P10MAV	BFA **	LOWER	12.00000	1.00000	12.00000	12.00000	.
67	P10ACHT	INT	ACTIVE	7.00000	1.00000	6.00000	12.00000	.
68	P10SAR	INT **	UPPER	10.00000	1.00000	9.00000	10.00000	.
69	P10NIGHT	INT **	UPPER	15.00000	1.00000	6.00000	15.00000	.
70	P10COLS	INT **	LOWER	8.00000	1.00000	8.00000	13.00000	.
71	P11WD	INT **	LOWER	13.00000	1.00000	13.00000	16.00000	.
72	P11SAT	INT	ACTIVE	14.00000	1.00000	13.00000	18.00000	.
73	P11MAV	INT	ACTIVE	12.00000	1.00000	11.00000	12.00000	.
74	P11ACHT	INT **	LOWER	9.00000	1.00000	9.00000	12.00000	.
75	P11SAR	INT	ACTIVE	9.00000	1.00000	8.00000	10.00000	.
76	P11NIGHT	INT **	UPPER	15.00000	1.00000	6.00000	15.00000	.
77	P11COLS	INT	ACTIVE	12.00000	1.00000	6.00000	13.00000	.
78	P12WD	INT **	UPPER	16.00000	1.00000	15.00000	16.00000	.
79	P12SAT	INT	ACTIVE	16.00000	1.00000	16.00000	18.00000	.
80	P12MAV	INT	ACTIVE	10.00000	1.00000	10.00000	12.00000	.
81	P12ACHT	INT	ACTIVE	8.00000	1.00000	8.00000	12.00000	.
82	P12SAR	INT **	UPPER	10.00000	1.00000	9.00000	10.00000	.
83	P12NIGHT	INT	ACTIVE	11.00000	1.00000	6.00000	15.00000	.
84	P12COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
85	P13WD	INT **	LOWER	9.00000	1.00000	9.00000	11.00000	.
86	P13SAT	INT **	UPPER	12.00000	1.00000	7.00000	12.00000	.
87	P13MAV	INT	ACTIVE	6.00000	1.00000	5.00000	9.00000	.
88	P13ACHT	INT **	UPPER	7.00000	1.00000	2.00000	7.00000	.
89	P13SAR	INT **	UPPER	9.00000	1.00000	7.00000	9.00000	.
90	P13NIGHT	INT **	UPPER	10.00000	1.00000	5.00000	10.00000	.
91	P13COLS	INT	ACTIVE	22.00000	1.00000	17.00000	22.00000	.
92	P14WD	INT	ACTIVE	7.00000	1.00000	7.00000	12.00000	.
93	P14SAT	INT **	UPPER	13.00000	1.00000	9.00000	13.00000	.
94	P14MAV	INT	ACTIVE	10.00000	1.00000	6.00000	10.00000	.
95	P14ACHT	INT **	UPPER	8.00000	1.00000	7.00000	8.00000	.
96	P14SAR	INT	ACTIVE	8.00000	1.00000	7.00000	11.00000	.
97	P14NIGHT	INT **	UPPER	11.00000	1.00000	6.00000	11.00000	.
98	P14COLS	INT	ACTIVE	20.00000	1.00000	19.00000	25.00000	.
99	P15WD	INT	ACTIVE	14.00000	1.00000	14.00000	16.00000	.
100	P15SAT	INT	ACTIVE	17.00000	1.00000	16.00000	18.00000	.

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
101	P15MAV	INT	** LOWER	10.00000	1.00000	10.00000	12.00000	.
102	P15ACHI	INT	ACTIVE	8.00000	1.00000	8.00000	12.00000	.
103	P15SAR	INT	ACTIVE	9.00000	1.00000	8.00000	10.00000	.
104	P15NIGHT	INT	** UPPER	15.00000	1.00000	6.00000	15.00000	.
105	P15COLS	INT	ACTIVE	11.00000	1.00000	8.00000	13.00000	.
106	P16WD	INT	ACTIVE	7.00000	1.00000	6.00000	11.00000	.
107	P16SAT	INT	** UPPER	12.00000	1.00000	7.00000	12.00000	.
108	P16MAV	INT	** UPPER	9.00000	1.00000	7.00000	9.00000	.
109	P16ACHI	INT	** UPPER	7.00000	1.00000	4.00000	7.00000	.
110	P16SAR	INT	ACTIVE	8.00000	1.00000	6.00000	9.00000	.
111	P16NIGHT	INT	** UPPER	10.00000	1.00000	5.00000	10.00000	.
112	P16COLS	INT	** UPPER	22.00000	1.00000	17.00000	22.00000	.
113	P17WD	INT	ACTIVE	13.00000	1.00000	10.00000	13.00000	.
114	P17SAT	INT	ACTIVE	6.00000	1.00000	4.00000	7.00000	.
115	P17MAV	INT	** LOWER	3.00000	1.00000	3.00000	5.00000	.
116	P17ACHI	BFX	** LOWER	6.00000	1.00000	6.00000	6.00000	.
117	P17SAR	INT	** LOWER	3.00000	1.00000	3.00000	6.00000	.
118	P17NIGHT	INT	** LOWER	2.00000	1.00000	2.00000	4.00000	.
119	P17COLS	INT	** LOWER	12.00000	1.00000	12.00000	18.00000	.
120	P18WD	INT	** UPPER	12.00000	1.00000	10.00000	12.00000	.
121	P18SAT	INT	** UPPER	13.00000	1.00000	8.00000	13.00000	.
122	P18MAV	INT	ACTIVE	10.00000	1.00000	7.00000	10.00000	.
123	P18ACHI	INT	ACTIVE	7.00000	1.00000	4.00000	8.00000	.
124	P18SAR	INT	ACTIVE	8.00000	1.00000	8.00000	11.00000	.
125	P18NIGHT	INT	ACTIVE	8.00000	1.00000	6.00000	11.00000	.
126	P18COLS	INT	** LOWER	19.00000	1.00000	19.00000	25.00000	.
127	P19WD	INT	** LOWER	13.00000	1.00000	13.00000	16.00000	.
128	P19SAT	INT	** LOWER	17.00000	1.00000	17.00000	18.00000	.
129	P19MAV	INT	** LOWER	11.00000	1.00000	11.00000	12.00000	.
130	P19ACHI	INT	ACTIVE	7.00000	1.00000	7.00000	12.00000	.
131	P19SAR	INT	ACTIVE	9.00000	1.00000	8.00000	10.00000	.
132	P19NIGHT	INT	ACTIVE	14.00000	1.00000	6.00000	15.00000	.
133	P19COLS	INT	** UPPER	13.00000	1.00000	8.00000	13.00000	.
134	P20WD	INT	** LOWER	14.00000	1.00000	14.00000	16.00000	.
135	P20SAT	INT	ACTIVE	16.00000	1.00000	15.00000	18.00000	.
136	P20MAV	INT	** LOWER	10.00000	1.00000	10.00000	12.00000	.
137	P20ACHI	INT	** LOWER	9.00000	1.00000	9.00000	12.00000	.
138	P20SAR	INT	ACTIVE	9.00000	1.00000	8.00000	10.00000	.
139	P20NIGHT	INT	ACTIVE	13.00000	1.00000	6.00000	15.00000	.
140	P20COLS	INT	** UPPER	11.00000	1.00000	8.00000	13.00000	.
141	P21WD	INT	** LOWER	10.00000	1.00000	10.00000	11.00000	.
142	P21SAT	INT	ACTIVE	12.00000	1.00000	8.00000	12.00000	.
143	P21MAV	INT	** LOWER	8.00000	1.00000	8.00000	9.00000	.
144	P21ACHI	INT	** LOWER	6.00000	1.00000	6.00000	7.00000	.
145	P21SAR	BFX	** LOWER	9.00000	1.00000	9.00000	9.00000	.
146	P21NIGHT	INT	** LOWER	5.00000	1.00000	5.00000	10.00000	.
147	P21COLS	INT	** LOWER	9.00000	1.00000	9.00000	11.00000	.
148	P22WD	INT	** LOWER	10.00000	1.00000	10.00000	13.00000	.
149	P22SAT	INT	ACTIVE	7.00000	1.00000	4.00000	7.00000	.
150	P22MAV	INT	** LOWER	3.00000	1.00000	3.00000	5.00000	.

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
151	P22ACHT	INT	** LOWER	6.00000	1.00000	6.00000	6.00000	.
152	P22SAR	INT	** LOWER	3.00000	1.00000	3.00000	6.00000	.
153	P22NIGHT	INT	** UPPER	4.00000	1.00000	2.00000	4.00000	.
154	P22COLS	INT	** LOWER	12.00000	1.00000	12.00000	18.00000	.
155	P23WD	INT	** LOWER	8.00000	1.00000	8.00000	12.00000	.
156	P23SAT	INT	ACTIVE	12.00000	1.00000	8.00000	13.00000	.
157	P23MAV	INT	** UPPER	10.00000	1.00000	7.00000	10.00000	.
158	P23ACHT	INT	ACTIVE	8.00000	1.00000	5.00000	10.00000	.
159	P23SAR	INT	ACTIVE	8.00000	1.00000	7.00000	11.00000	.
160	P23NIGHT	INT	** UPPER	11.00000	1.00000	6.00000	11.00000	.
161	P23COLS	INT	** UPPER	12.00000	1.00000	10.00000	12.00000	.
162	P24WD	INT	ACTIVE	14.00000	1.00000	14.00000	16.00000	.
163	P24SAT	INT	ACTIVE	17.00000	1.00000	17.00000	18.00000	.
164	P24MAV	INT	ACTIVE	10.00000	1.00000	9.00000	12.00000	.
165	P24ACHT	INT	ACTIVE	9.00000	1.00000	8.00000	12.00000	.
166	P24SAR	INT	** UPPER	10.00000	1.00000	9.00000	10.00000	.
167	P24NIGHT	INT	ACTIVE	11.00000	1.00000	6.00000	15.00000	.
168	P24COLS	INT	** UPPER	13.00000	1.00000	8.00000	13.00000	.
169	P25WD	INT	ACTIVE	14.00000	1.00000	14.00000	16.00000	.
170	P25SAT	INT	ACTIVE	16.00000	1.00000	15.00000	18.00000	.
171	P25MAV	INT	** UPPER	12.00000	1.00000	11.00000	12.00000	.
172	P25ACHT	INT	ACTIVE	9.00000	1.00000	8.00000	12.00000	.
173	P25SAR	INT	** UPPER	10.00000	1.00000	8.00000	10.00000	.
174	P25NIGHT	INT	** UPPER	15.00000	1.00000	6.00000	15.00000	.
175	P25COLS	INT	** LOWER	8.00000	1.00000	8.00000	13.00000	.
176	P26WD	INT	** LOWER	14.00000	1.00000	14.00000	16.00000	.
177	P26SAT	INT	** LOWER	16.00000	1.00000	16.00000	18.00000	.
178	P26MAV	INT	** LOWER	10.00000	1.00000	10.00000	12.00000	.
179	P26ACHT	INT	** LOWER	7.00000	1.00000	7.00000	12.00000	.
180	P26SAR	INT	ACTIVE	9.00000	1.00000	8.00000	10.00000	.
181	P26NIGHT	INT	** UPPER	15.00000	1.00000	6.00000	15.00000	.
182	P26COLS	INT	ACTIVE	13.00000	1.00000	8.00000	13.00000	.
183	P27WD	INT	** LOWER	2.00000	1.00000	2.00000	6.00000	.
184	P27SAT	INT	** UPPER	10.00000	1.00000	2.00000	10.00000	.
185	P27MAV	INT	ACTIVE	6.00000	1.00000	2.00000	6.00000	.
186	P27ACHT	INT	** LOWER	2.00000	1.00000	2.00000	6.00000	.
187	P27SAR	INT	** LOWER	2.00000	1.00000	2.00000	5.00000	.
188	P27NIGHT	INT	** LOWER	2.00000	1.00000	2.00000	6.00000	.
189	P27COLS	INT	** LOWER	6.00000	1.00000	6.00000	9.00000	.
190	P28WD	INT	** UPPER	16.00000	1.00000	15.00000	16.00000	.
191	P28SAT	INT	ACTIVE	16.00000	1.00000	15.00000	18.00000	.
192	P28MAV	INT	ACTIVE	10.00000	1.00000	10.00000	12.00000	.
193	P28ACHT	INT	** UPPER	12.00000	1.00000	9.00000	12.00000	.
194	P28SAR	INT	** UPPER	10.00000	1.00000	8.00000	10.00000	.
195	P28NIGHT	INT	ACTIVE	12.00000	1.00000	6.00000	15.00000	.
196	P28COLS	INT	** LOWER	8.00000	1.00000	8.00000	13.00000	.
197	P29WD	INT	** LOWER	14.00000	1.00000	14.00000	16.00000	.
198	P29SAT	INT	ACTIVE	16.00000	1.00000	14.00000	18.00000	.
199	P29MAV	INT	ACTIVE	10.00000	1.00000	9.00000	12.00000	.
200	P29ACHT	INT	ACTIVE	8.00000	1.00000	8.00000	12.00000	.

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
201	P29SAR	INT	ACTIVE	8.00000	1.00000	7.00000	10.00000	.
202	P29NIGHT	INT	** UPPER	15.00000	1.00000	6.00000	15.00000	.
203	P29COLS	INT	** UPPER	13.00000	1.00000	8.00000	13.00000	.
204	P30WD	INT	** UPPER	15.00000	1.00000	9.00000	15.00000	.
205	P30SAT	INT	ACTIVE	8.00000	1.00000	7.00000	10.00000	.
206	P30MAV	INT	** UPPER	6.00000	1.00000	4.00000	6.00000	.
207	P30ACHT	INT	** UPPER	6.00000	1.00000	3.00000	6.00000	.
208	P30SAR	INT	** UPPER	6.00000	1.00000	3.00000	6.00000	.
209	P30NIGHT	INT	** UPPER	3.00000	1.00000	2.00000	3.00000	.
210	P30COLS	INT	** UPPER	16.00000	1.00000	10.00000	16.00000	.
211	P31WD	INT	** LOWER	8.00000	1.00000	8.00000	12.00000	.
212	P31SAT	INT	** UPPER	13.00000	1.00000	9.00000	13.00000	.
213	P31MAV	INT	ACTIVE	10.00000	1.00000	9.00000	10.00000	.
214	P31ACHT	INT	** UPPER	8.00000	1.00000	6.00000	8.00000	.
215	P31SAR	INT	** LOWER	8.00000	1.00000	8.00000	11.00000	.
216	P31NIGHT	INT	** UPPER	11.00000	1.00000	6.00000	11.00000	.
217	P31COLS	INT	** LOWER	19.00000	1.00000	19.00000	25.00000	.
218	P32WD	INT	ACTIVE	13.00000	1.00000	12.00000	16.00000	.
219	P32SAT	INT	ACTIVE	17.00000	1.00000	17.00000	18.00000	.
220	P32MAV	INT	ACTIVE	10.00000	1.00000	9.00000	12.00000	.
221	P32ACHT	INT	ACTIVE	8.00000	1.00000	8.00000	12.00000	.
222	P32SAR	INT	ACTIVE	9.00000	1.00000	9.00000	10.00000	.
223	P32NIGHT	INT	** UPPER	15.00000	1.00000	6.00000	15.00000	.
224	P32COLS	INT	ACTIVE	12.00000	1.00000	8.00000	13.00000	.
225	P33WD	INT	** LOWER	9.00000	1.00000	9.00000	12.00000	.
226	P33SAT	INT	** LOWER	9.00000	1.00000	9.00000	13.00000	.
227	P33MAV	INT	** UPPER	10.00000	1.00000	8.00000	10.00000	.
228	P33ACBT	INT	** UPPER	8.00000	1.00000	6.00000	8.00000	.
229	P33SAR	INT	ACTIVE	8.00000	1.00000	8.00000	11.00000	.
230	P33NIGHT	INT	** UPPER	11.00000	1.00000	6.00000	11.00000	.
231	P33COLS	INT	ACTIVE	22.00000	1.00000	19.00000	25.00000	.
232	P34WD	INT	ACTIVE	13.00000	1.00000	10.00000	13.00000	.
233	P34SAT	INT	** LOWER	4.00000	1.00000	4.00000	7.00000	.
234	P34MAV	INT	** UPPER	5.00000	1.00000	3.00000	5.00000	.
235	P34ACHT	UFX	** LOWER	6.00000	1.00000	6.00000	6.00000	.
236	P34SAR	INT	** LOWER	3.00000	1.00000	3.00000	6.00000	.
237	P34NIGHT	INT	** LOWER	2.00000	1.00000	2.00000	4.00000	.
238	P34COLS	INT	** LOWER	12.00000	1.00000	12.00000	18.00000	.
239	P35WD	INT	ACTIVE	13.00000	1.00000	10.00000	16.00000	.
240	P35SAT	INT	** LOWER	9.00000	1.00000	9.00000	12.00000	.
241	P35MAV	INT	** LOWER	5.00000	1.00000	5.00000	7.00000	.
242	P35ACHT	INT	** LOWER	4.00000	1.00000	4.00000	7.00000	.
243	P35SAR	INT	** LOWER	3.00000	1.00000	3.00000	6.00000	.
244	P35NIGHT	INT	ACTIVE	3.00000	1.00000	2.00000	3.00000	.
245	P35COLS	INT	** UPPER	13.00000	1.00000	9.00000	13.00000	.
246	P36WD	INT	** UPPER	12.00000	1.00000	10.00000	12.00000	.
247	P35SAT	INT	** UPPER	13.00000	1.00000	10.00000	13.00000	.
248	P36MAV	INT	** LOWER	6.00000	1.00000	6.00000	10.00000	.
249	P36ACHT	INT	ACTIVE	9.00000	1.00000	6.00000	10.00000	.
250	P36SAR	INT	** LOWER	9.00000	1.00000	9.00000	11.00000	.

NUMBER	NAME	TYPE		STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
251	P36NIGHT	INT		ACTIVE	10.00000	1.00000	6.00000	11.00000	.
252	P36COLS	INT	**	LOWER	10.00000	1.00000	10.00000	12.00000	.
253	P37WD	UEA	**	LOWER	16.00000	1.00000	16.00000	16.00000	.
254	P37SAT	INT		ACTIVE	17.00000	1.00000	16.00000	18.00000	.
255	P37MAV	INT		ACTIVE	10.00000	1.00000	10.00000	12.00000	.
256	P37ACHT	INT		ACTIVE	7.00000	1.00000	7.00000	12.00000	.
257	P37SAR	INT		ACTIVE	9.00000	1.00000	8.00000	10.00000	.
258	P37NIGHT	INT	**	UPPER	15.00000	1.00000	6.00000	15.00000	.
259	P37COLS	INT		ACTIVE	10.00000	1.00000	8.00000	13.00000	.

C O L U M N S

PRINT OPTION - FULL   MAP NAME   SPECIALIZED - NO   VALUE OF OBJECTIVE = 2[illegible]02.00000
NAME - CAGNALL   OBJ - TOTALS   RHS - RHS   BND = BOUNDS   DPCOBJ = -1.0000   DPCRHS = 1.0000
DIR - MAXIMIZE   COST -   COLS -   RNG = RANGES   DPCBND = 0.0000   DPCRNG = 0.0000

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COST	BND LOWER	BND UPPER	MARGINAL
1	P01WD	INT	** LOWER	2.00000	1.00000	2.00000	6.00000	.
2	P01SAT	INT	UPPER	10.00000	1.00000	2.00000	10.00000	1.00000
3	P01MAV	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
4	P01ACHT	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
5	P01SAN	INT	** LOWER	2.00000	1.00000	2.00000	5.00000	.
6	P01NIGHT	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
7	P01COLS	INT	ACTIVE	7.00000	1.00000	6.00000	9.00000	.
8	P02WD	INT	ACTIVE	13.00000	1.00000	13.00000	16.00000	.
9	P02SAT	INT	UPPER	18.00000	1.00000	14.00000	18.00000	1.00000
10	P02MAV	UFA	LOWER	12.00000	1.00000	12.00000	12.00000	1.00000
11	P02ACHT	INT	ACTIVE	10.00000	1.00000	8.00000	12.00000	.
12	P02SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
13	P02NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
14	P02COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
15	P03WD	INT **	UPPER	12.00000	1.00000	9.00000	12.00000	.
16	P03SAT	INT	UPPER	13.00000	1.00000	10.00000	13.00000	1.00000
17	P03MAV	INT	UPPER	10.00000	1.00000	9.00000	10.00000	1.00000
18	P03ACHT	INT	UPPER	8.00000	1.00000	6.00000	8.00000	1.00000
19	P03SAN	INT	ACTIVE	9.00000	1.00000	8.00000	11.00000	.
20	P03NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
21	P03COLS	INT **	UPPER	25.00000	1.00000	19.00000	25.00000	.
22	P04WD	INT **	UPPER	16.00000	1.00000	14.00000	16.00000	.
23	P04SAT	INT	UPPER	18.00000	1.00000	15.00000	18.00000	1.00000
24	P04MAV	INT	UPPER	12.00000	1.00000	10.00000	12.00000	1.00000
25	P04ACHT	INT	ACTIVE	10.00000	1.00000	8.00000	12.00000	.
26	P04SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
27	P04NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
28	P04COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
29	P05WD	INT **	UPPER	12.00000	1.00000	8.00000	12.00000	.
30	P05SAT	INT	UPPER	13.00000	1.00000	9.00000	13.00000	1.00000
31	P05MAV	INT	UPPER	10.00000	1.00000	8.00000	10.00000	1.00000
32	P05ACHT	INT	ACTIVE	8.00000	1.00000	4.00000	10.00000	.
33	P05SAN	INT	ACTIVE	9.00000	1.00000	7.00000	11.00000	.
34	P05NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
35	P05COLS	INT **	UPPER	12.00000	1.00000	10.00000	12.00000	.
36	P06WD	INT **	UPPER	12.00000	1.00000	9.00000	12.00000	.
37	P06SAT	INT	UPPER	13.00000	1.00000	10.00000	13.00000	1.00000
38	P06MAV	INT	UPPER	10.00000	1.00000	8.00000	10.00000	1.00000
39	P06ACHT	INT	UPPER	8.00000	1.00000	5.00000	8.00000	5.00000
40	P06SAN	INT	ACTIVE	10.00000	1.00000	9.00000	11.00000	.
41	P06NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
42	P06COLS	INT **	UPPER	25.00000	1.00000	19.00000	25.00000	.
43	P07WD	INT **	UPPER	12.00000	1.00000	8.00000	12.00000	.
44	P07SAT	INT	UPPER	13.00000	1.00000	9.00000	13.00000	1.00000
45	P07MAV	INT	UPPER	10.00000	1.00000	8.00000	10.00000	1.00000
46	P07ACHT	INT	UPPER	8.00000	1.00000	7.00000	8.00000	1.00000
47	P07SAN	INT	ACTIVE	9.00000	1.00000	8.00000	11.00000	.
48	P07NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
49	P07COLS	INT **	LOWER	19.00000	1.00000	19.00000	25.00000	.
50	P08WD	INT	ACTIVE	3.00000	1.00000	2.00000	6.00000	.

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
1	IHO	LE	BINDING	462.00000	.	-INF	462.00000	-1.00000
2	ISAT	LE	SLACK	522.00000	29.00000	-INF	551.00000	.
3	IMAV	LE	SLACK	358.00000	4.00000	-INF	362.00000	.
4	IACHI	LE	SLACK	314.00000	43.00000	-INF	357.00000	.
5	ISAR	LE	BINDING	313.00000	.	-INF	313.00000	-1.00000
6	INIGHT	LE	SLACK	411.00000	.	-INF	411.00000	.
7	ICOLS	LE	BINDING	522.00000	.	-INF	522.00000	-1.00000
8	TOTALS	FR	SLACK	2902.00000	-2902.00000	-INF	+INF	.
9	P01	ULE **	BINDING	39.00000	.	30.00000	39.00000	.
10	P02	ULE	SLACK	91.00000	6.00000	84.00000	97.00000	.
11	P03	ULE	SLACK	88.00000	1.00000	77.00000	89.00000	.
12	P04	ULE	SLACK	94.00000	3.00000	84.00000	97.00000	.
13	P05	ULE	SLACK	75.00000	1.00000	69.00000	76.00000	.
14	P06	ULE	SLACK	89.00000	.	77.00000	89.00000	.
15	P07	ULE	SLACK	82.00000	7.00000	77.00000	89.00000	.
16	P08	ULE **	BINDING	39.00000	.	30.00000	39.00000	.
17	P09	ULE	SLACK	75.00000	1.00000	69.00000	76.00000	.
18	P10	ULE	SLACK	91.00000	6.00000	84.00000	97.00000	.
19	P11	ULE	SLACK	93.00000	4.00000	84.00000	97.00000	.
20	P12	ULE	SLACK	94.00000	3.00000	84.00000	97.00000	.
21	P13	ULE	SLACK	80.00000	1.00000	75.00000	81.00000	.
22	P14	ULE	SLACK	81.00000	8.00000	77.00000	89.00000	.
23	P15	ULE	SLACK	93.00000	4.00000	84.00000	97.00000	.
24	P16	ULE **	BINDING	75.00000	6.00000	75.00000	81.00000	.
25	P17	ULE	SLACK	53.00000	4.00000	45.00000	57.00000	.
26	P18	ULE	SLACK	81.00000	8.00000	77.00000	89.00000	.
27	P19	ULE	SLACK	89.00000	8.00000	84.00000	97.00000	.
28	P20	ULE	SLACK	96.00000	1.00000	84.00000	97.00000	.
29	P21	ULE	BINDING	65.00000	.	59.00000	65.00000	-1.00000
30	P22	ULE	SLACK	56.00000	1.00000	45.00000	57.00000	.
31	P23	ULE	SLACK	76.00000	.	69.00000	76.00000	.
32	P24	ULE	SLACK	96.00000	1.00000	84.00000	97.00000	.
33	P25	ULE	SLACK	96.00000	1.00000	84.00000	97.00000	.
34	P26	ULE	SLACK	92.00000	5.00000	84.00000	97.00000	.
35	P27	ULE **	BINDING	39.00000	.	30.00000	39.00000	.
36	P28	ULE	SLACK	96.00000	1.00000	84.00000	97.00000	.
37	P29	ULE	SLACK	91.00000	6.00000	84.00000	97.00000	.
38	P30	ULE	SLACK	62.00000	.	60.00000	62.00000	.
39	P31	ULE	SLACK	82.00000	7.00000	77.00000	89.00000	.
40	P32	ULE	SLACK	84.00000	13.00000	84.00000	97.00000	.
41	P33	ULE	SLACK	88.00000	1.00000	77.00000	89.00000	.
42	P34	ULE	SLACK	53.00000	4.00000	45.00000	57.00000	.
43	P35	ULE	SLACK	61.00000	5.00000	50.00000	66.00000	.
44	P36	ULE	SLACK	75.00000	1.00000	69.00000	76.00000	.
45	P37	ULE	SLACK	92.00000	5.00000	84.00000	97.00000	.
46	C1410AD	LE **	BINDING	.	.	-INF	.	.
47	C1609AD	LE	SLACK	-1.00000	1.00000	-INF	.	.
48	C0912AD	LE	SLACK	-1.00000	1.00000	-INF	.	.
49	C1211AD	LE **	BINDING	.	.	-INF	.	.
50	C1110AD	LE **	BINDING	.	.	-INF	.	.

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
51	C1302WD	LE	** BINDING	.	.	-INF	.	.
52	C0235WD	LE	** BINDING	.	.	-INF	.	.
53	C3517WD	LE	** BINDING	.	.	-INF	.	.
54	C1720WD	LE	SLACK	-1.00000	1.00000	-INF	.	.
55	C2024WD	LE	SLACK	.	.	-INF	.	.
56	C2415WD	LE	SLACK	.	.	-INF	.	.
57	C1525WD	LE	SLACK	.	.	-INF	.	.
58	C2529WD	LE	SLACK	.	.	-INF	.	.
59	C2926WD	LE	SLACK	.	.	-INF	.	.
60	C2604WD	LE	SLACK	.	.	-INF	.	.
61	C0410WD	LE	SLACK	.	.	-INF	.	.
62	C1012WD	LE	SLACK	.	.	-INF	.	.
63	C1220WD	LE	SLACK	.	.	-INF	.	.
64	C2617WD	LE	SLACK	.	.	-INF	.	.
65	C2109SAT	LE	SLACK	.	.	-INF	.	.
66	C0918SAT	LE	SLACK	.	.	-INF	.	.
67	C1811SAT	LE	SLACK	-5.00000	5.00000	-INF	.	.
68	C1102SAT	LE	SLACK	.	.	-INF	.	.
69	C0229SAT	LE	SLACK	.	.	-INF	.	.
70	C2928SAT	LE	SLACK	.	.	-INF	.	.
71	C2804SAT	LE	SLACK	.	.	-INF	.	.
72	C0420SAT	LE	SLACK	.	.	-INF	.	.
73	C2025SAT	LE	SLACK	.	.	-INF	.	.
74	C2510SAT	LE	SLACK	.	.	-INF	.	.
75	C1012SAT	LE	SLACK	.	.	-INF	.	.
76	C1226SAT	LE	SLACK	.	.	-INF	.	.
77	C2637SAT	LE	SLACK	.	.	-INF	.	.
78	C3715SAT	LE	SLACK	.	.	-INF	.	.
79	C1532SAT	LE	SLACK	.	.	-INF	.	.
80	C3224SAT	LE	SLACK	.	.	-INF	.	.
81	C2419SAT	LE	SLACK	.	.	-INF	.	.
82	C1613MAV	LE	BINDING	.	.	-INF	.	-1.00000
83	C1309MAV	LE	SLACK	-1.00000	1.00000	-INF	.	.
84	C0914MAV	LE	SLACK	.	.	-INF	.	.
85	C1419MAV	LE	SLACK	.	.	-INF	.	.
86	C1829MAV	LE	SLACK	.	.	-INF	.	.
87	C2932MAV	LE	BINDING	.	.	-INF	.	-1.00000
88	C3223MAV	LE	BINDING	.	.	-INF	.	-2.00000
89	C2324MAV	LE	SLACK	-2.00000	2.00000	-INF	.	.
90	C2420MAV	LE	SLACK	.	.	-INF	.	.
91	C2004MAV	LE	SLACK	.	.	-INF	.	.
92	C0415MAV	LE	SLACK	.	.	-INF	.	.
93	C1537MAV	LE	SLACK	.	.	-INF	.	.
94	C3728MAV	LE	SLACK	.	.	-INF	.	.
95	C2612MAV	LE	SLACK	.	.	-INF	.	.
96	C1226MAV	LE	SLACK	.	.	-INF	.	.
97	C2617MAV	LE	SLACK	.	.	-INF	.	.
98	C1925MAV	LE	SLACK	.	.	-INF	.	.
99	C2511MAV	LE	SLACK	.	.	-INF	.	.
100	C1110MAV	LE	SLACK	.	.	-INF	.	.

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
101	C1018ACHI	LE	BINDING	.	.	-INF	.	-1.00000
102	C1613ACHI	LE	BINDING	.	.	-INF	.	-2.00000
103	C1305ACHI	LE	SLACK	-1.00000	1.00000	-INF	.	.
104	C0537ACHI	LE	BINDING	.	.	-INF	.	-1.00000
105	C3719ACHI	LE	BINDING	.	.	-INF	.	-2.00000
106	C1426ACHI	LE	BINDING	.	.	-INF	.	-3.00000
107	C2606ACHI	LE	BINDING	.	.	-INF	.	-4.00000
108	C0509ACHI	LE	SLACK	-2.00000	2.00000	-INF	.	.
109	C0723ACHI	LE	SLACK	.	.	-INF	.	.
110	C2312ACHI	LE	SLACK	.	.	-INF	.	.
111	C1232ACHI	LE	BINDING	.	.	-INF	.	-1.00000
112	C1229ACHI	LE	BINDING	.	.	-INF	.	-2.00000
113	C2904ACHI	LE	BINDING	.	.	-INF	.	-3.00000
114	C0415ACHI	LE	BINDING	.	.	-INF	.	-4.00000
115	C1502ACHI	LE	BINDING	.	.	-INF	.	-5.00000
116	C0236ACHI	LE	BINDING	.	.	-INF	.	-6.00000
117	C1625ACHI	LE	SLACK	-2.00000	2.00000	-INF	.	.
118	C2524ACHI	LE	SLACK	.	.	-INF	.	.
119	C2420ACHI	LE	SLACK	.	.	-INF	.	.
120	C2011ACHI	LE	SLACK	.	.	-INF	.	.
121	C1128ACHI	LE	SLACK	.	.	-INF	.	.
122	C2109SAN	LE	** BINDING	.	.	-INF	.	.
123	C0905SAN	LE	** BINDING	.	.	-INF	.	.
124	C0514SAN	LE	** BINDING	.	.	-INF	.	.
125	C1407SAN	LE	** BINDING	.	.	-INF	.	.
126	C0718SAN	LE	** BINDING	.	.	-INF	.	.
127	C1816SAN	LE	** BINDING	.	.	-INF	.	.
128	C1633SAN	LE	** BINDING	.	.	-INF	.	.
129	C3303SAN	LE	** BINDING	.	.	-INF	.	.
130	C0129SAN	LE	** BINDING	.	.	-INF	.	.
131	C2911SAN	LE	** BINDING	.	.	-INF	.	.
132	C3115SAN	LE	** BINDING	.	.	-INF	.	.
133	C1306SAN	LE	SLACK	-1.00000	1.00000	-INF	.	.
134	C0636SAN	LE	** BINDING	.	.	-INF	.	.
135	C1626SAN	LE	** BINDING	.	.	-INF	.	.
136	C2632SAN	LE	SLACK	.	.	-INF	.	.
137	C3237SAN	LE	SLACK	.	.	-INF	.	.
138	C3711SAN	LE	SLACK	.	.	-INF	.	.
139	C1102SAN	LE	SLACK	.	.	-INF	.	.
140	C0204SAN	LE	SLACK	.	.	-INF	.	.
141	C0420SAN	LE	SLACK	.	.	-INF	.	.
142	C2015SAN	LE	SLACK	.	.	-INF	.	.
143	C1519SAN	LE	SLACK	.	.	-INF	.	.
144	C1928SAN	LE	SLACK	.	.	-INF	.	.
145	C2325SAN	LE	SLACK	.	.	-INF	.	.
146	C2524SAN	LE	SLACK	.	.	-INF	.	.
147	C2412SAN	LE	SLACK	.	.	-INF	.	.
148	C1210SAN	LE	SLACK	.	.	-INF	.	.

C O N S T R A I N T S

PRINT OPTION = FULL   MAP NAME =   SPECIAL/POS = NO   VALUE OF OBJECTIVE = 2902.00000
NAME = PANNELL   OUT = TOTALS   RHS = RHS   BND = BOUNDS   RPSMALL = 1.0000   EPSRHS = 1.0000
DIR = MINIMIZE   COST =   CROS =   RNG = RANGES   RPSMULT = 0.0000   RPCHRHS = 0.0000

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
1	TWD	LE	BINDING	462.00000	.	-INF	462.00000	-1.00000
2	ISAT	LE	SLACK	522.00000	29.00000	-INF	551.00000	.
3	IMAV	LE	SLACK	358.00000	4.00000	-INF	362.00000	.
4	IACBI	LE	SLACK	314.00000	43.00000	-INF	357.00000	.
5	ISAR	LE	BINDING	313.00000	.	-INF	313.00000	-1.00000
6	INIGHT	LE	SLACK	411.00000	.	-INF	411.00000	.
7	ICOLS	LE	BINDING	522.00000	.	-INF	522.00000	-1.00000
8	TOTALS	FR	SLACK	2902.00000	-2902.00000	-INF	+INF	.
9	P01	BLE **	BINDING	39.00000	.	30.00000	39.00000	.
10	P02	BLE	SLACK	91.00000	6.00000	84.00000	97.00000	.
11	P03	BLE	SLACK	88.00000	1.00000	77.00000	89.00000	.
12	P04	BLE	SLACK	94.00000	3.00000	84.00000	97.00000	.
13	P05	BLE	SLACK	75.00000	1.00000	69.00000	76.00000	.
14	P06	BLE	SLACK	89.00000	.	77.00000	89.00000	.
15	P07	BLE	SLACK	82.00000	7.00000	77.00000	89.00000	.
16	P08	BLE **	BINDING	39.00000	.	30.00000	39.00000	.
17	P09	BLE	SLACK	75.00000	1.00000	69.00000	76.00000	.
18	P10	BLE	SLACK	91.00000	6.00000	84.00000	97.00000	.
19	P11	BLE	SLACK	93.00000	4.00000	84.00000	97.00000	.
20	P12	BLE	SLACK	94.00000	3.00000	84.00000	97.00000	.
21	P13	BLE	SLACK	80.00000	1.00000	75.00000	81.00000	.
22	P14	BLE	SLACK	81.00000	8.00000	77.00000	89.00000	.
23	P15	BLE	SLACK	93.00000	4.00000	84.00000	97.00000	.
24	P16	BLE **	BINDING	75.00000	6.00000	75.00000	81.00000	.
25	P17	BLE	SLACK	53.00000	4.00000	45.00000	57.00000	.
26	P18	BLE	SLACK	81.00000	8.00000	77.00000	89.00000	.
27	P19	BLE	SLACK	89.00000	8.00000	84.00000	97.00000	.
28	P20	BLE	SLACK	96.00000	1.00000	84.00000	97.00000	.
29	P21	BLE	BINDING	65.00000	.	59.00000	65.00000	-1.00000
30	P22	BLE	SLACK	56.00000	1.00000	45.00000	57.00000	.
31	P23	BLE	SLACK	76.00000	.	69.00000	76.00000	.
32	P24	BLE	SLACK	96.00000	1.00000	84.00000	97.00000	.
33	P25	BLE	SLACK	96.00000	1.00000	84.00000	97.00000	.
34	P26	BLE	SLACK	92.00000	5.00000	84.00000	97.00000	.
35	P27	BLE **	BINDING	39.00000	.	30.00000	39.00000	.
36	P28	BLE	SLACK	96.00000	1.00000	84.00000	97.00000	.
37	P29	BLE	SLACK	91.00000	6.00000	84.00000	97.00000	.
38	P30	BLE	SLACK	62.00000	.	60.00000	62.00000	.
39	P31	BLE	SLACK	82.00000	7.00000	77.00000	89.00000	.
40	P32	BLE	SLACK	84.00000	13.00000	84.00000	97.00000	.
41	P33	BLE	SLACK	88.00000	1.00000	77.00000	89.00000	.
42	P34	BLE	SLACK	53.00000	4.00000	45.00000	57.00000	.
43	P35	BLE	SLACK	61.00000	5.00000	50.00000	66.00000	.
44	P36	BLE	SLACK	75.00000	1.00000	69.00000	76.00000	.
45	P37	BLE	SLACK	92.00000	5.00000	84.00000	97.00000	.
46	C1416WD	LE **	BINDING	.	.	-INF	.	.
47	C1609WD	LE	SLACK	-1.00000	1.00000	-INF	.	.
48	C0932WD	LE	SLACK	-1.00000	1.00000	-INF	.	.
49	C1211WD	LE **	BINDING	.	.	-INF	.	.
50	C1119WD	LE **	BINDING	.	.	-INF	.	.

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
51	P08SAT	INT	UPPER	10.00000	1.00000	2.00000	10.00000	1.00000
52	P08MAV	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
53	P08ACHI	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
54	P08SAR	INT	** LOWER	2.00000	1.00000	2.00000	5.00000	.
55	P08NIGHT	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
56	P08COLS	INT	** LOWER	6.00000	1.00000	6.00000	9.00000	.
57	P09WD	INT	** UPPER	12.00000	1.00000	7.00000	12.00000	.
58	P09SAT	INT	UPPER	13.00000	1.00000	8.00000	13.00000	1.00000
59	P09MAV	INT	UPPER	10.00000	1.00000	6.00000	10.00000	1.00000
60	P09ACHI	INT	UPPER	10.00000	1.00000	5.00000	10.00000	1.00000
61	P09SAR	INT	ACTIVE	9.00000	1.00000	7.00000	11.00000	.
62	P09NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
63	P09COLS	INT	** LOWER	10.00000	1.00000	10.00000	12.00000	.
64	P10WD	INT	** UPPER	16.00000	1.00000	14.00000	16.00000	.
65	P10SAT	INT	UPPER	18.00000	1.00000	15.00000	18.00000	1.00000
66	P10MAV	UFX	LOWER	12.00000	1.00000	12.00000	12.00000	1.00000
67	P10ACHI	INT	ACTIVE	7.00000	1.00000	6.00000	12.00000	.
68	P10SAR	INT	** UPPER	10.00000	1.00000	9.00000	10.00000	.
69	P10NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
70	P10COLS	INT	** UPPER	13.00000	1.00000	8.00000	13.00000	.
71	P11WD	INT	ACTIVE	13.00000	1.00000	13.00000	16.00000	.
72	P11SAT	INT	UPPER	18.00000	1.00000	13.00000	18.00000	1.00000
73	P11MAV	INT	UPPER	12.00000	1.00000	11.00000	12.00000	1.00000
74	P11ACHI	INT	UPPER	12.00000	1.00000	9.00000	12.00000	1.00000
75	P11SAR	INT	** UPPER	10.00000	1.00000	8.00000	10.00000	.
76	P11NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
77	P11COLS	INT	** UPPER	13.00000	1.00000	8.00000	13.00000	.
78	P12WD	INT	** UPPER	16.00000	1.00000	15.00000	16.00000	.
79	P12SAT	INT	UPPER	18.00000	1.00000	16.00000	18.00000	1.00000
80	P12MAV	INT	UPPER	12.00000	1.00000	10.00000	12.00000	1.00000
81	P12ACHI	INT	ACTIVE	10.00000	1.00000	8.00000	12.00000	.
82	P12SAR	INT	** UPPER	10.00000	1.00000	9.00000	10.00000	.
83	P12NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
84	P12COLS	INT	** UPPER	13.00000	1.00000	8.00000	13.00000	.
85	P13WD	INT	** UPPER	11.00000	1.00000	9.00000	11.00000	.
86	P13SAT	INT	UPPER	12.00000	1.00000	7.00000	12.00000	1.00000
87	P13MAV	INT	UPPER	9.00000	1.00000	5.00000	9.00000	2.00000
88	P13ACHI	INT	UPPER	7.00000	1.00000	2.00000	7.00000	3.00000
89	P13SAR	INT	** UPPER	9.00000	1.00000	7.00000	9.00000	.
90	P13NIGHT	INT	UPPER	10.00000	1.00000	5.00000	10.00000	1.00000
91	P13COLS	INT	** UPPER	22.00000	1.00000	17.00000	22.00000	.
92	P14WD	INT	ACTIVE	11.00000	1.00000	7.00000	12.00000	.
93	P14SAT	INT	UPPER	13.00000	1.00000	9.00000	13.00000	1.00000
94	P14MAV	INT	UPPER	10.00000	1.00000	6.00000	10.00000	1.00000
95	P14ACHI	INT	UPPER	8.00000	1.00000	7.00000	8.00000	1.00000
96	P14SAR	INT	ACTIVE	9.00000	1.00000	7.00000	11.00000	.
97	P14NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
98	P14COLS	INT	** LOWER	17.00000	1.00000	19.00000	25.00000	.
99	P15WD	INT	** UPPER	16.00000	1.00000	14.00000	16.00000	.
100	P15SAT	INT	UPPER	18.00000	1.00000	16.00000	18.00000	1.00000

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
101	P15MAV	INT	UPPER	12.00000	1.00000	10.00000	12.00000	1.00000
102	P15ACHT	INT	ACTIVE	10.00000	1.00000	8.00000	12.00000	.
103	P15SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
104	P15NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
105	P15COLS	INT	ACTIVE	12.00000	1.00000	8.00000	13.00000	.
106	P16WD	INT **	UPPER	11.00000	1.00000	6.00000	11.00000	.
107	P16SAT	INT	UPPER	12.00000	1.00000	7.00000	12.00000	1.00000
108	P16MAV	INT	UPPER	9.00000	1.00000	7.00000	9.00000	1.00000
109	P16ACHT	INT	UPPER	7.00000	1.00000	4.00000	7.00000	1.00000
110	P16SAN	INT	ACTIVE	9.00000	1.00000	6.00000	9.00000	.
111	P16NIGHT	INT	UPPER	10.00000	1.00000	5.00000	10.00000	1.00000
112	P16COLS	INT	ACTIVE	17.00000	1.00000	17.00000	22.00000	.
113	P17WD	INT **	UPPER	13.00000	1.00000	10.00000	13.00000	.
114	P17SAT	INT	UPPER	7.00000	1.00000	4.00000	7.00000	1.00000
115	P17MAV	INT	UPPER	5.00000	1.00000	3.00000	5.00000	1.00000
116	P17ACHT	BFX	LOWER	6.00000	1.00000	6.00000	6.00000	1.00000
117	P17SAN	INT **	UPPER	6.00000	1.00000	3.00000	6.00000	.
118	P17NIGHT	INT	UPPER	4.00000	1.00000	2.00000	4.00000	1.00000
119	P17COLS	INT **	LOWER	12.00000	1.00000	12.00000	18.00000	.
120	P18WD	INT **	UPPER	12.00000	1.00000	10.00000	12.00000	.
121	P18SAT	INT	UPPER	13.00000	1.00000	8.00000	13.00000	1.00000
122	P18MAV	INT	UPPER	10.00000	1.00000	7.00000	10.00000	1.00000
123	P18ACHT	INT	ACTIVE	7.00000	1.00000	4.00000	8.00000	.
124	P18SAN	INT	ACTIVE	9.00000	1.00000	8.00000	11.00000	.
125	P18NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
126	P18COLS	INT **	LOWER	19.00000	1.00000	19.00000	25.00000	.
127	P19WD	INT	ACTIVE	13.00000	1.00000	13.00000	16.00000	.
128	P19SAT	INT	UPPER	18.00000	1.00000	17.00000	18.00000	1.00000
129	P19MAV	INT	UPPER	12.00000	1.00000	11.00000	12.00000	1.00000
130	P19ACHT	INT	ACTIVE	8.00000	1.00000	7.00000	12.00000	.
131	P19SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
132	P19NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
133	P19COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
134	P20WD	INT **	UPPER	16.00000	1.00000	14.00000	16.00000	.
135	P20SAT	INT	UPPER	18.00000	1.00000	15.00000	18.00000	1.00000
136	P20MAV	INT	UPPER	12.00000	1.00000	10.00000	12.00000	1.00000
137	P20ACHT	INT	UPPER	12.00000	1.00000	9.00000	12.00000	1.00000
138	P20SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
139	P20NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
140	P20COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
141	P21WD	INT	LOWER	10.00000	1.00000	10.00000	11.00000	-1.00000
142	P21SAT	INT **	UPPER	12.00000	1.00000	8.00000	12.00000	.
143	P21MAV	INT **	UPPER	9.00000	1.00000	8.00000	9.00000	.
144	P21ACHT	INT **	UPPER	7.00000	1.00000	6.00000	7.00000	.
145	P21SAN	BFX	LOWER	9.00000	1.00000	9.00000	9.00000	-1.00000
146	P21NIGHT	INT	ACTIVE	9.00000	1.00000	5.00000	10.00000	.
147	P21COLS	INT	LOWER	9.00000	1.00000	9.00000	11.00000	-1.00000
148	P22WD	INT **	LOWER	10.00000	1.00000	10.00000	13.00000	.
149	P22SAT	INT	UPPER	7.00000	1.00000	4.00000	7.00000	1.00000
150	P22MAV	INT	UPPER	5.00000	1.00000	3.00000	5.00000	1.00000

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
151	P22ACHI	UFX	LOWER	6.00000	1.00000	6.00000	6.00000	1.00000
152	P22SAN	INT **	UPPER	6.00000	1.00000	3.00000	6.00000	.
153	P22NIGHT	INT	UPPER	4.00000	1.00000	2.00000	4.00000	1.00000
154	P22COLS	INT **	UPPER	18.00000	1.00000	12.00000	18.00000	.
155	P23WD	INT	ACTIVE	11.00000	1.00000	8.00000	12.00000	.
156	P23SAT	INT	UPPER	13.00000	1.00000	8.00000	13.00000	1.00000
157	P23MAV	INT	UPPER	10.00000	1.00000	7.00000	10.00000	1.00000
158	P23ACHI	INT	UPPER	10.00000	1.00000	5.00000	10.00000	1.00000
159	P23SAN	INT	ACTIVE	9.00000	1.00000	7.00000	11.00000	.
160	P23NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
161	P23COLS	INT **	UPPER	12.00000	1.00000	10.00000	12.00000	.
162	P24WD	INT **	UPPER	16.00000	1.00000	14.00000	16.00000	.
163	P24SAT	INT	UPPER	18.00000	1.00000	17.00000	18.00000	1.00000
164	P24MAV	INT	UPPER	12.00000	1.00000	9.00000	12.00000	1.00000
165	P24ACHI	INT	UPPER	12.00000	1.00000	8.00000	12.00000	1.00000
166	P24SAN	INT **	UPPER	10.00000	1.00000	9.00000	10.00000	.
167	P24NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
168	P24COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
169	P25WD	INT **	UPPER	16.00000	1.00000	14.00000	16.00000	.
170	P25SAT	INT	UPPER	18.00000	1.00000	15.00000	18.00000	1.00000
171	P25MAV	INT	UPPER	12.00000	1.00000	11.00000	12.00000	1.00000
172	P25ACHI	INT	UPPER	12.00000	1.00000	8.00000	12.00000	1.00000
173	P25SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
174	P25NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
175	P25COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
176	P26WD	INT **	UPPER	16.00000	1.00000	14.00000	16.00000	.
177	P26SAT	INT	UPPER	18.00000	1.00000	16.00000	18.00000	1.00000
178	P26MAV	INT	UPPER	12.00000	1.00000	10.00000	12.00000	1.00000
179	P26ACHI	INT	ACTIVE	8.00000	1.00000	7.00000	12.00000	.
180	P26SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
181	P26NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
182	P26COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
183	P27WD	INT	ACTIVE	3.00000	1.00000	2.00000	6.00000	.
184	P27SAT	INT	UPPER	10.00000	1.00000	2.00000	10.00000	1.00000
185	P27MAV	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
186	P27ACHI	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
187	P27SAN	INT **	LOWER	2.00000	1.00000	2.00000	5.00000	.
188	P27NIGHT	INT	UPPER	6.00000	1.00000	2.00000	6.00000	1.00000
189	P27COLS	INT **	LOWER	6.00000	1.00000	6.00000	9.00000	.
190	P28WD	INT **	UPPER	16.00000	1.00000	15.00000	16.00000	.
191	P28SAT	INT	UPPER	18.00000	1.00000	15.00000	18.00000	1.00000
192	P28MAV	INT	UPPER	12.00000	1.00000	10.00000	12.00000	1.00000
193	P28ACHI	INT	UPPER	12.00000	1.00000	9.00000	12.00000	1.00000
194	P28SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
195	P28NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
196	P28COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
197	P29WD	INT **	UPPER	16.00000	1.00000	14.00000	16.00000	.
198	P29SAT	INT	UPPER	18.00000	1.00000	14.00000	18.00000	1.00000
199	P29MAV	INT	ACTIVE	10.00000	1.00000	9.00000	12.00000	.
200	P29ACHI	INT	ACTIVE	10.00000	1.00000	8.00000	12.00000	.

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
201	P29SAM	INT	ACTIVE	9.00000	1.00000	7.00000	10.00000	.
202	P29NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
203	P29COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.
204	P30WD	INT **	UPPER	15.00000	1.00000	9.00000	15.00000	.
205	P30SAT	INT	UPPER	10.00000	1.00000	7.00000	10.00000	1.00000
206	P30MAV	INT	UPPER	6.00000	1.00000	4.00000	6.00000	1.00000
207	P30ACHT	INT	UPPER	6.00000	1.00000	3.00000	6.00000	1.00000
208	P30SAM	INT **	UPPER	6.00000	1.00000	3.00000	6.00000	.
209	P30NIGHT	INT	UPPER	3.00000	1.00000	2.00000	3.00000	1.00000
210	P30COLS	INT **	UPPER	16.00000	1.00000	10.00000	16.00000	.
211	P31WD	INT **	UPPER	12.00000	1.00000	8.00000	12.00000	.
212	P31SAT	INT	UPPER	13.00000	1.00000	9.00000	13.00000	1.00000
213	P31MAV	INT	UPPER	10.00000	1.00000	9.00000	10.00000	1.00000
214	P31ACHT	INT	UPPER	8.00000	1.00000	6.00000	8.00000	1.00000
215	P31SAM	INT	ACTIVE	9.00000	1.00000	6.00000	11.00000	.
216	P31NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
217	P31COLS	INT **	LOWER	19.00000	1.00000	19.00000	25.00000	.
218	P32WD	INT	ACTIVE	13.00000	1.00000	12.00000	16.00000	.
219	P32SAT	INT	UPPER	18.00000	1.00000	17.00000	18.00000	1.00000
220	P32MAV	INT	ACTIVE	10.00000	1.00000	9.00000	12.00000	.
221	P32ACHT	INT	ACTIVE	10.00000	1.00000	8.00000	12.00000	.
222	P32SAM	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
223	P32NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
224	P32COLS	INT **	LOWER	8.00000	1.00000	8.00000	13.00000	.
225	P33WD	INT **	UPPER	12.00000	1.00000	9.00000	12.00000	.
226	P33SAT	INT	UPPER	13.00000	1.00000	9.00000	13.00000	1.00000
227	P33MAV	INT	UPPER	10.00000	1.00000	8.00000	10.00000	1.00000
228	P33ACHT	INT	UPPER	8.00000	1.00000	6.00000	8.00000	1.00000
229	P33SAM	INT	ACTIVE	9.00000	1.00000	8.00000	11.00000	.
230	P33NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
231	P33COLS	INT **	UPPER	25.00000	1.00000	19.00000	25.00000	.
232	P34WD	INT **	UPPER	13.00000	1.00000	10.00000	13.00000	.
233	P34SAT	INT	UPPER	7.00000	1.00000	4.00000	7.00000	1.00000
234	P34MAV	INT	UPPER	5.00000	1.00000	3.00000	5.00000	1.00000
235	P34ACHT	DFX	LOWER	6.00000	1.00000	6.00000	6.00000	1.00000
236	P34SAM	INT	ACTIVE	6.00000	1.00000	3.00000	6.00000	.
237	P34NIGHT	INT	UPPER	4.00000	1.00000	2.00000	4.00000	1.00000
238	P34COLS	INT **	LOWER	12.00000	1.00000	12.00000	18.00000	.
239	P35WD	INT	ACTIVE	13.00000	1.00000	10.00000	16.00000	.
240	P35SAT	INT	UPPER	12.00000	1.00000	9.00000	12.00000	1.00000
241	P35MAV	INT	UPPER	7.00000	1.00000	5.00000	7.00000	1.00000
242	P35ACHT	INT	UPPER	7.00000	1.00000	4.00000	7.00000	1.00000
243	P35SAM	INT **	UPPER	6.00000	1.00000	3.00000	6.00000	.
244	P35NIGHT	INT	UPPER	3.00000	1.00000	2.00000	3.00000	1.00000
245	P35COLS	INT **	UPPER	13.00000	1.00000	9.00000	13.00000	.
246	P36WD	INT **	UPPER	12.00000	1.00000	10.00000	12.00000	.
247	P36SAT	INT	UPPER	13.00000	1.00000	10.00000	13.00000	1.00000
248	P36MAV	INT	ACTIVE	9.00000	1.00000	6.00000	10.00000	.
249	P36ACHT	INT	UPPER	10.00000	1.00000	6.00000	10.00000	7.00000
250	P36SAM	INT	ACTIVE	10.00000	1.00000	9.00000	11.00000	.

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
251	P36NIGHT	INT	UPPER	11.00000	1.00000	6.00000	11.00000	1.00000
252	P36COLS	INT **	LOWER	10.00000	1.00000	10.00000	12.00000	.
253	P37DD	DFX **	LOWER	16.00000	1.00000	16.00000	16.00000	.
254	P37SAT	INT	UPPER	18.00000	1.00000	16.00000	18.00000	1.00000
255	P37MAV	INT	UPPER	12.00000	1.00000	10.00000	12.00000	1.00000
256	P37ACBT	INT	ACTIVE	8.00000	1.00000	7.00000	12.00000	.
257	P37SAN	INT **	UPPER	10.00000	1.00000	8.00000	10.00000	.
258	P37NIGHT	INT	UPPER	15.00000	1.00000	6.00000	15.00000	1.00000
259	P37COLS	INT **	UPPER	13.00000	1.00000	8.00000	13.00000	.

APPENDIX G

APPENDIX G

SCHEDULER'S HANDBOOK

This appendix is designed to provide a simple step by step guide for using the scheduling system developed during research into optimizing sortie allocation in an A-7D squadron. This interactive system is designed for the scheduler to use a computer terminal in the squadron which gives access to a central computer facility and the LP program. The actions required can be categorized into three phases: preparation, input, and analysis. These three phases will be explained in chronological order.

The first phase, preparation, involves collecting and formatting required data so that it will be available in the proper sequence for input into the computer. The initial step is to establish the projected planning sorties of each type for the upcoming training cycle. This information must be broken down according to the maximum numbers by WD, SAT, MAV, SAR, NIGHT, and COLS sorties. In addition, for each pilot assigned or attached for flying, the following data must be collected:

Pilot training category (CT or IQT/MQT)

Pilot category (Primary or Staff)

Pilot's current or projected mission status (MR or MS)

Experience level (Experienced or Inexperienced)

Pilots designated as IPs

GCC level assigned (A, B, or C)

Additional tasking (Night or SAR)

Pilot ranking for each type sortie

Collection of this data can be simplified by generation of a local form with columns arranged similar to the example in Figure 7. With the data available and formatted for the input process, it will take from twenty to thirty minutes to input the information to the computer.

The input phase is not complicated and does not take any great amount of training to accomplish. The first step is to gain access to the computer system. The procedures required to accomplish this task are normally generated locally and will be provided by the local DPI. Once access to the system is obtained, the scheduler must bring the FORTRAN computer assisted scheduling program into the local working space for execution. When the program is executed, a series of questions appear on the display device. The questions and required responses are illustrated in Figure 8.

In addition to the questions which will appear on the display device, the program contains several error statements which will appear when improper data is input. The computer error messages which may be generated and the required responses are illustrated in Figure 9.

After the data for each of the pilots has been entered the scheduler must input 999 for the last pilot number to direct the program to perform a subroutine to generate the proper format for the input of the output from the FORTRAN computer assisted scheduling program to the LP package for generation of a solution. To generate the solution, the output from the FORTRAN computer assisted scheduling program must be input into the LP package used by the system. This is

PLANNING SORTIES	WD	SAT	MAV	ACBT	SAR	NIGHT	COLS	TOTAL

PILOT NUMBER	TNG CAT	IQT/MQT TNG TIME	PILOT CAT	MSN STATUS	EXPER LVL	IP	GCC LVL	ADDITIONAL TASKING		RANKING				
								NIGHT	SAR	WD	SAT	MAV	ACBT	SAR

Figure 7

Sortie Allocation Work Sheet

Question	Response
1. Total number of pilots?	Enter the number of pilots who will be scheduled for flying during the training cycle.
2. Maximum number of WD, SAT, MAV, ACBT, SAR, Night, COLS sorties?	Enter in order the maximum number of each type sortie forecast to be available for the training cycle.
3. Pilot number?	Each pilot is numbered consecutively from 1 to the maximum entered for the question in number 1. Enter 999 when all the pilots have been entered.
4. Training category--CT=1, IQT/MQT=2?	If a pilot is entered or already in CT enter 1. If a pilot is going through IQT/MQT enter 2.
5. Months to complete IQT/MQT--1,2,3,4?	Enter the number of months the pilot is expected to take to complete training in months from 1 to 4.
6. Pilot category--Primary=1, Staff=2?	Enter a 1 if the pilot is a primary unit pilot and a 2 if the pilot is a staff pilot.
7. Status after IQT/MQT--MR=1, MS=2?	If the pilot will enter CT and become MR after completion of training enter 1. If the pilot will not become MR then enter 2.
8. Pilot status--MR=1, MS=2?	Enter a 1 for an MR pilot and 2 for a non MR pilot.
9. Experience=1, Inexperience=2?	If a pilot is classified as experienced enter a 1 otherwise enter a 2.

Figure 8

Question/Response

Question	Response
10. Is pilot an IP--Yes=1, No=2?	If pilot serves as an IP or SEFE enter a 1, if not enter a 2.
11. GCC level--A=1, B=2, C=3?	Enter the appropriate number for the assigned GCC level: A=1, B=2, C=3.
12. Ranking for WD, SAT, MAV, ACBT, SAR sorties?	Enter in order the ranking for each type sortie for each pilot.

Figure 8 (Continued)

Statement	Response
1. Illegal entry try again	Check and reenter required data. This will normally occur when an entry is not one of the inputs allowed. For example, inputting a 3 when only a 1 or 2 entry is allowed.
2. Max pilots allowed is 50 must change program	This will be printed if the number entered for the total number of pilots in question 1, Figure 9, exceeds 50. If more than 50 pilots are assigned the program will have to be modified to make the arrays and matrices larger to accommodate the additional data.
3. Ranks must be in Range 1 to # pilots = " "	This entry is printed when a number is entered greater than the total number of pilots entered in response to question 12, Figure 9.
4. Conflict with pilot " " ranks = " "	This entry is printed when two pilots with the same ranking are entered in response to question 12, Figure 9.

Figure 9

Statement/Response

accomplished by following the locally established procedures to run the program. Once the program is run, the output can be routed to a printer or displayed on the local display device depending on local capabilities. Generation of the computer solution completes the input phase and provides the product which is evaluated in the final phase.

The computer solution generated by this process allows the scheduler to evaluate sortie requirements on three different levels. The first level is made up of the gross total figures for each sortie type relative to the input for the planning factors for the training period. The next higher level includes a breakout of total sorties by pilot, but does not break the total sorties down by type. The last level consists of a breakout of sorties by type for each pilot.

Evaluation of the first level involves interpretation of the first eight rows of the CONSTRAINTS section of the computer solution as reproduced in Figure 10. The entries in the RHS UPPER column represents the planning factors input by the scheduler. The entries in the ROW ACTIVITY column are the solutions for the number of sorties required or desired. The entry in the SLACK column shows the difference between the input and the computer solution (ROW ACTIVITY entry). Positive entries in the SLACK column indicate an excess capacity, while negative entries indicate a shortage. The other column of interest is the MARGINAL column. An entry in the MARGINAL column indicates the rate at which the total sorties changes per unit change of the type of sortie. A negative sign indicates an improvement in the total sorties and a positive sign indicates a degradation in the total sorties. By comparing the maximum and minimum solutions the scheduler can arrive

MAXIMIZE

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
1	TWD	LE	SLACK	446.00000	11.00000	-INF	457.00000	.
2	TSAT	LE	SLACK	517.00000	32.00000	-INF	549.00000	.
3	TMAV	LE	SLACK	355.00000	4.00000	-INF	359.00000	.
4	TACBT	LE	SLACK	295.00000	9.00000	-INF	304.00000	.
5	TSAR	LE	BINDING	285.00000	.	-INF	285.00000	-1.00000
6	TNIGHT	LE	SLACK	331.00000	64.00000	-INF	395.00000	.
7	TCOLS	LE	SLACK	518.00000	16.00000	-INF	534.00000	.
8	TOTALS	FR	SLACK	2747.00000	-2747.00000	-INF	+INF	.

MINIMIZE

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
1	TWD	LE	SLACK	404.00000	53.00000	-INF	457.00000	.
2	TSAT	LE	SLACK	435.00000	114.00000	-INF	549.00000	.
3	TMAV	LE	SLACK	297.00000	62.00000	-INF	359.00000	.
4	TACBT	LE	SLACK	249.00000	55.00000	-INF	304.00000	.
5	TSAR	LE	SLACK	285.00000	.	-INF	285.00000	.
6	TNIGHT	LE	SLACK	228.00000	167.00000	-INF	395.00000	.
7	TCOLS	LE	SLACK	443.00000	91.00000	-INF	534.00000	.
8	TOTALS	FR	SLACK	2341.00000	-2341.00000	-INF	+INF	

Figure 10

Level One

at an idea of the range of sorties which could be used efficiently under either limited or plentiful sortie availability.

Using Figure 10 an example can be given to clarify the process of interpretation for this level. The same inputs were used in both the maximum and minimum solutions depicted. From line eight it can be seen that the sorties needed to meet the needs of all the pilots would be 2,341 at a minimum level or 2,747 at the maximum level. When 285 sorties are input as the SAR (line 5) planning factor, the ACTIVITY column shows a solution of 285 sorties with no excess apparent in the SLACK column. The -1 entry in the MARGINAL column for SAR sorties indicates that if an additional SAR sortie could be generated the total number of sorties would improve by one. Evaluating the WD row (line 1) shows there is excess WD sorties available at both maximum (53 excess) and minimum (11 excess) sortie rates. The difference between the two rates, 42 (53-11) sorties, should not be converted to another type of sortie or returned to another unit to satisfy their needs since these sorties can be efficiently used by the unit. Only eleven of the WD sorties should be considered for conversion to another type of sortie or returned for use by another unit. Since the configuration of both SAT (line 2) and MAV (line 3) aircraft are compatible with the SAR mission and there are excess sorties of both types, the excess sorties of either type could be converted to SAR missions and the total number of sorties flown could be efficiently increased by one for each sortie converted to a SAR mission. This same process is applicable for any type sortie where aircraft configurations are compatible.

Level one provided a general view of the total sortie requirements by type. Level two provides a more refined view by allowing the

total allocation for each pilot to be evaluated. To simplify the explanation of the information available in level two, pilot P04 will be used as an example.

From the minimize section of Figure 11 the minimum number of sorties which should be allocated to P04 (line 12) would be seventy three (RHS LOWER). The maximum number should be eighty six (RHS UPPER). The difference between the maximum and minimum sorties is thirteen (SLACK) which could be used should P04 have problems which required extra training. The -1 (MARGINAL) value indicates the total number of sorties for the unit could be improved by one sortie if P04 were to be given one less sortie. However, since P04 is already at a minimum level, he should not be given any fewer sorties unless he is to be regressed to a lower GCC level.

From the maximum section of Figure 11 the maximum number of sorties which P04 should be allocated is again seventy three (ROW ACTIVITY). Since both the maximum and minimum solutions are the same, the scheduler should make every attempt to allocate seventy three sorties to P04. The -4 (MARGINAL) entry means every additional sortie allocated to P04 would result in a change of four in the total sorties for the unit. This is true because if P04 were given one additional sortie the program would also have to allocate additional sorties to other pilots.

When the maximum and minimum solutions (ROW ACTIVITY) for a pilot differ as is the case for P10 (line 18, Figure 11) significant information can be deduced. The difference between the lower and upper rate of flying should be regarded as the minimum number of sorties held in reserve for the pilot. For P10, four sorties would be

MAXIMIZE

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
9	P01	BLE	SLACK	36.00000	3.00000	30.00000	39.00000	.
10	P02	BLE	SLACK	83.00000	3.00000	73.00000	86.00000	.
11	P03	BLE	SLACK	78.00000	3.00000	69.00000	81.00000	.
12	P04	BLE	BINDING	73.00000	13.00000	73.00000	86.00000	-4.00000
13	P05	BLE	SLACK	67.00000	1.00000	56.00000	68.00000	.
14	P06	BLE	SLACK	78.00000	3.00000	69.00000	81.00000	.
15	P07	BLE	SLACK	79.00000	2.00000	69.00000	81.00000	.
16	P08	BLE	SLACK	39.00000	.	30.00000	39.00000	.
17	P09	BLE	SLACK	64.00000	4.00000	56.00000	68.00000	.
18	P10	BLE	SLACK	77.00000	9.00000	73.00000	86.00000	.

MINIMIZE

NUMBER	NAME	TYPE	STATUS	ROW ACTIVITY	SLACK	RHS LOWER	RHS UPPER	MARGINAL
9	P01	BLE	BINDING	30.00000	9.00000	30.00000	39.00000	-1.00000
10	P02	BLE	BINDING	73.00000	13.00000	73.00000	86.00000	-1.00000
11	P03	BLE	BINDING	69.00000	12.00000	69.00000	81.00000	-1.00000
12	P04	BLE	BINDING	73.00000	13.00000	73.00000	86.00000	-1.00000
13	P05	BLE	BINDING	56.00000	12.00000	56.00000	68.00000	-1.00000
14	P06	BLE	BINDING	69.00000	12.00000	69.00000	81.00000	-1.00000
15	P07	BLE	BINDING	69.00000	12.00000	69.00000	81.00000	-1.00000
16	P08	BLE	BINDING	30.00000	9.00000	30.00000	39.00000	-1.00000
17	P09	BLE	BINDING	56.00000	12.00000	56.00000	68.00000	-1.00000
18	P10	BLE	BINDING	73.00000	13.00000	73.00000	86.00000	-1.00000

Figure 11

Level Two

held in reserve and the remaining nine (SLACK) of the maximum solution could be used for another purpose or not used at all.

Level three provides the greatest amount of detail for the scheduler. It allows an evaluation of the various sortie types for each pilot. Pilot P01 will be used to explain the evaluation process for this level using Figure 12.

Both the minimum and maximum solutions for pilot P01 WD, ABCT, SAR, NIGHT, and COLS are equal as indicated in the print-out (lines 1, 4, 5, 6, and 7). This indicates P01 should be allocated the same number of these sorties under most conditions. The solution further shows that P01 should be scheduled for between five and ten SAT sorties even though the acceptable range would be from two (BND LOWER) to ten (BND UPPER). The MAV sortie spread is from two to six which is the same as the acceptable limits (BND LOWER to BND UPPER).

An important factor is identified by the -1 (MARGINAL) entry (line 5). The number of SAR sorties available are a limiting factor which was previously noted in level one. If more SAR sorties were made available, the number of SAR sorties allocated to P01 would increase under the maximum allocation condition. Likewise, the total number of sorties would increase by one sortie for each sortie allocated to P01.

A negative entry in the MARGINAL column is an indication of who should be given more (maximum condition) or fewer (minimum condition) sorties. The larger the number the greater the effect on the total sorties for each sortie either given or taken away. A positive entry in the MARGINAL column is an indication of who should not be given more (maximum condition) or fewer (minimum condition) sorties.

MAXIMUM

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
1	P01WD	INT	ACTIVE	2.00000	1.00000	2.00000	6.00000	.
2	P01SAT	INT**	UPPER	10.00000	1.00000	2.00000	10.00000	.
3	P01MAV	INT**	UPPER	6.00000	1.00000	2.00000	6.00000	.
4	P01ACBT	INT**	UPPER	6.00000	1.00000	2.00000	6.00000	.
5	P01SAR	INT	LOWER	2.00000	1.00000	2.00000	5.00000	-1.00000
6	P01NIGHT	INT**	UPPER	4.00000	1.00000	2.00000	4.00000	.
7	P01COLS	INT**	UPPER	9.00000	1.00000	6.00000	9.00000	.
8	P02WD	INT	ACTIVE	13.00000	1.00000	13.00000	16.00000	.
9	P02SAT	INT**	UPPER	18.00000	1.00000	14.00000	18.00000	.
10	P02MAV	BFX**	LOWER	12.00000	1.00000	12.00000	12.00000	.
11	P02ACBT	INT**	UPPER	10.00000	1.00000	8.00000	10.00000	.
12	P02SAR	INT	LOWER	10.00000	1.00000	10.00000	12.00000	-1.00000

MINIMUM

NUMBER	NAME	TYPE	STATUS	COL ACTIVITY	OBJ COEF	BND LOWER	BND UPPER	MARGINAL
1	P01WD	INT*	LOWER	2.00000	1.00000	2.00000	6.00000	.
2	P01SAT	INT	ACTIVE	5.00000	1.00000	2.00000	10.00000	.
3	P01MAV	INT**	LOWER	2.00000	1.00000	2.00000	6.00000	.
4	P01ACBT	INT**	UPPER	6.00000	1.00000	2.00000	6.00000	.
5	P01SAR	INT**	LOWER	2.00000	1.00000	2.00000	5.00000	.
6	P01NIGHT	INT**	UPPER	4.00000	1.00000	2.00000	4.00000	.
7	P01COLS	INT*	UPPER	9.00000	1.00000	6.00000	9.00000	.
8	P02WD	INT**	LOWER	13.00000	1.00000	13.00000	16.00000	.
9	P02SAT	INT	ACTIVE	15.00000	1.00000	14.00000	18.00000	.
10	P02MAV	BFX**	LOWER	12.00000	1.00000	12.00000	12.00000	.
11	P02ACBT	INT**	LOWER	8.00000	1.00000	8.00000	10.00000	.
12	P02SAR	INT**	LOWER	10.00000	1.00000	10.00000	12.00000	.

Figure 12

Level Three

The guidelines provided in this handbook apply to the computer generated print-outs from the Control Data Corporation APEX III program and the Burroughs' TEMPO program. Both of these programs are for solving linear or integer programming models.

BIBLIOGRAPHY

BIBLIOGRAPHY

Books

1. Control Data Corporation, APEX III Reference Manual, Minneapolis: Data Services Publications, 1975.

2. Cooper, L., and Steinberg, D., Methods and Application of Linear Programming. Philadelphia: W. B. Saunders, 1974.

3. Glicksman, A. M., An Introduction to Linear Programming and the Theory of Games. New York: John Wiley and Sons, 1963.

4. Nie, Norman H., and others, Statistical Package for the Social Sciences, 2d ed. New York: McGraw-Hill, 1975.

5. Trueman, Richard E., An Introduction to Quantitative Methods for Decision Making, 2d ed. New York: Holt, Rinehart and Winston, 1977.

Official Documents

6. Air Force Inspection and Safety Center. Functional Management Inspection of Tactical Air Forces Aircrew Training PN 77-603. Norton AFB: Department of the Air Force, 1977.

7. Air Force Regulation 60-1, Flight Management. Washington: Department of the Air Force, 2 January 1975.

8. Air Force Pamphlet 173-13, USAF Cost and Planning Factors. Washington: Department of the Air Force, 31 May 1979.

9. RAND Corporation. The Doss Prototype. Department of the Air Force, #WN-9484-PR, 1976.

10. RAND Corporation. Scheduling Aircrews and Aircraft: Problems of Resource Allocations in the Strategic Air Command. Department of the Air Force, #R-1610-PR, 1975.

11. Tactical Air Command Manual 25-5, Programmed Flying Training Factors, Langley AFB: Department of the Air Force, 1 October 1974.

12. Tactical Air Command Manual 51-50, Vol I, Tactical Fighter/Reconnaissance Aircrew Training. Langley AFB: Department of the Air Force, 1 July 1979.

13. Tactical Air Command Manual 51-50, Vol III, A-7 Aircrew Training. Langley AFB: Department of the Air Force, 16 August 1979.

14. Tactical Air Command Manual 51-365 (Draft), TAC Automated Flying Training Management System. Langley AFB: Department of the Air Force, 23 January 1980.

Periodicals and Articles

15. "An Air Force Almanac," Air Force Magazine, May 1979, pp. 135-149.

16. Ellis, B. J. "Readiness," Air Force Policy Letter for Commanders, (July 1976), pp. 2-6.

17. Nutt, W. C. "Keeping Combat-Ready While Conserving Energy," Air Force Policy Letter for Commanders, (15 September 1979), p. 3.

18. "Maintaining the Readiness of Our Forces," Air Force Policy Letter for Commanders, (1 September 1976), p. 1.

Unpublished Material

19. Bartlett, Lieutenant Colonel Russell H. "Tactical Fighter Aircraft Programmed Flying Training Factoring Package." Unpublished Air War College research report, Air University, Maxwell AFB, Alabama, 1976.

20. Gibson, Colonel George H. "Consolidated Aircrew and Aircraft Scheduling." Unpublished Air War College research report, Air University, Maxwell AFB, Alabama, 1975.

21. Lafferty, Major Thomas E. "Aircrew Scheduling: A Fully Utilized Management Tool?" Unpublishes Air Command and Staff College research study, Air University, Maxwell AFB, Alabama, 1976.

22. Soden, Major James P. "An Analysis of Operational Flying Training for Tactical Aircrews." Unpublished Air Command and Staff College research study, Air University, Maxwell AFB, Alabama, 1977.

23. Strunk, Major Richard. "Can TAC Operations be Computer Scheduled?" Unpublished Air Command and Staff College research study, Air University, Maxwell AFB, Alabama, 1977.

24. Walsh, Major Robert P. "An Integrated Aircrew Training and Scheduling Program." Unpublished Air Command and Staff College research study, Air University, Maxwell AFB, Alabama, 1977.

INITIAL DISTRIBUTION LIST

1. Maj W. B. Allard
   110 N.W. 50th COURT
   Pompano Beach, Florida 33064

2. CPT R. E. Blankenship
   237 Bittersweet LN
   Lansing, Kansas 66043

3. Defense Documentation Center
   Cameron Station
   Alexandria, Virginia 22314

4. Library, U.S. Army Command and General Staff College
   Bell Hall
   Fort Leavenworth, Kansas 66027

5. LTCOL M. W. Schooff
   CGSC DREM
   Fort Leavenworth, Kansas 66027

80-CGSC-2385

END

DATE
FILMED

1-81

DTIC